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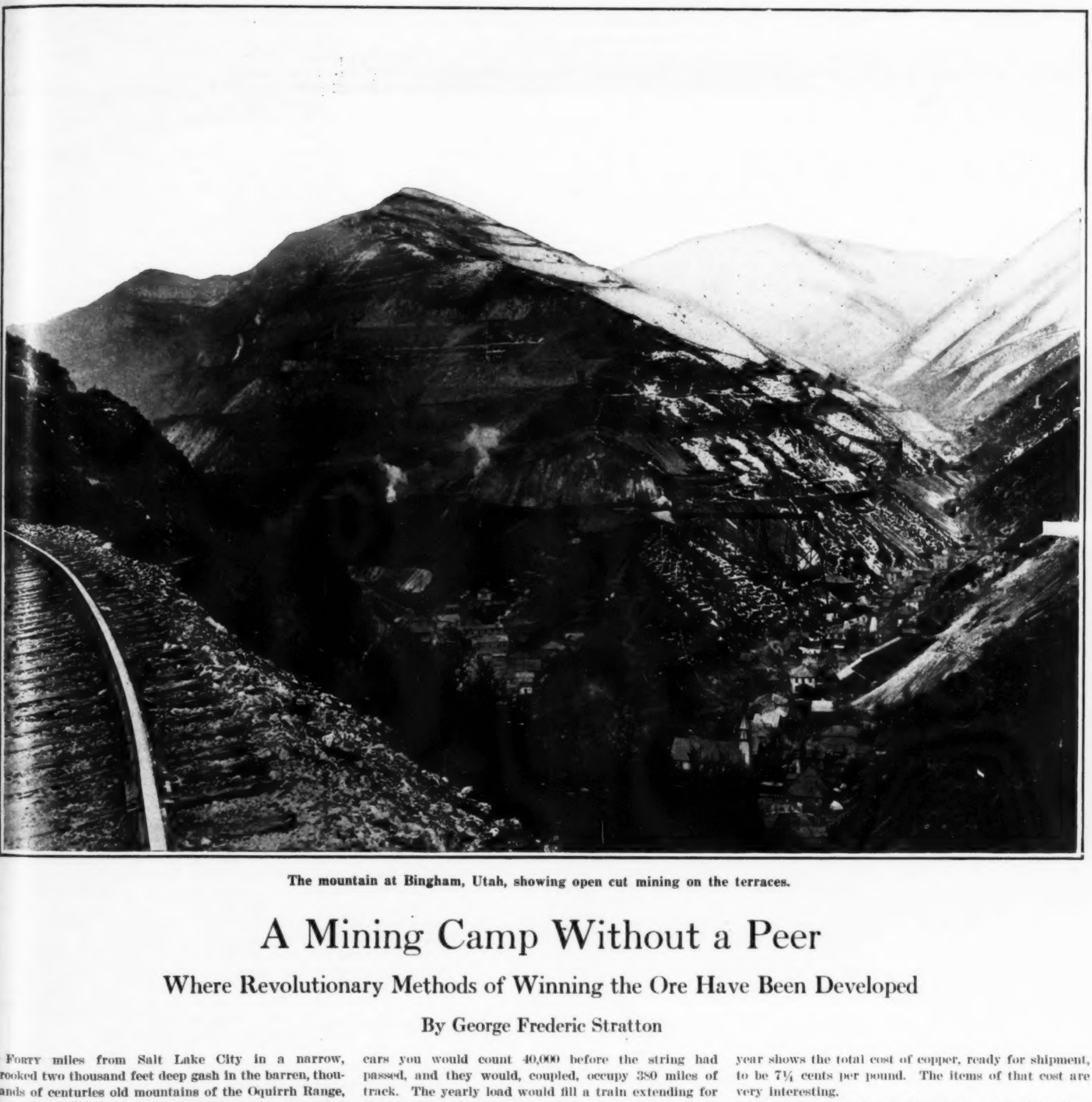


The mountain at Bingham, Utah, showing open cut mining on the terraces.

A Mining Camp Without a Peer

Where Revolutionary Methods of Winning the Ore Have Been Developed

By George Frederic Stratton

Forty miles from Salt Lake City in a narrow, crooked two thousand feet deep gash in the barren, thousands of centuries old mountains of the Oquirrh Range, is a group of mines, from which there was excavated and handled, last year, nearly one million cubic yards of ore and waste each week. At the time the engineers of the famous Culebra cut at Panama were making their highest excavating record they did not exceed three fourths of a million yards per week.

In those appalling Oquirrh Mountains steam shovels are working on terraces 1,500 feet above the canyon. At Culebra the highest peak handled was 500 feet above the canal level.

The Bingham camp is the greatest copper-producing camp in the world, and the operation of one company has resulted in the greatest open-mining wonder of the world, not even excepting the marvelous Kimberly Mines in Africa.

A million cubic yards means nothing to the ordinary man, but if it was loaded onto a string of heavy ore cars you would count 40,000 before the string had passed, and they would, coupled, occupy 380 miles of track. The yearly load would fill a train extending for 19,000 miles, three fourths of the journey round the equator. The metal obtained, gold, silver, copper, lead and zinc, reached in that year the total value of $20,980,000.

Over two thirds of the output is copper, making Bingham the greatest copper producer in the world, with the additional surprising condition that no other mine is operating such low-grade ore, its metal content ranging no higher than 2 per cent, and from that down to 1.4 per cent. At no other mine in this country has any attempt been made to take out and reduce ore of such low grade; and yet, the novel methods of the engineers and the splendidly efficient organization of men and machines have scaled down the production cost to such an astonishingly low figure as to earn great profits, even at the present low market price of copper. The report of the largest company of the group for the past year shows the total cost of copper, ready for shipment, to be 7¼ cents per pound. The items of that cost are very interesting.

Steam shovel mining, including taxes, administration, etc., is 21 cents per ton. Net transportation cost of carrying ore to mill, 15 cents. Milling, 37 cents, against which is a gold-silver credit, from the small percentage of those metals found, of 13 cents per ton, leaving a net cost for milled ore of 60 cents per ton, or 3.53 cents per pound of copper produced, to which must be added 3 cents per pound for smelting, refining and selling. Thus, the physical cost of producing the copper was 6.6 cents per pound, to which must be added stripping, exploration, depreciation and interest charges, bringing the actual cost of production up to 7¼ cents.

One glance at that table shows that to men—not minerals—is due the splendid earnings of this great mine, for in ordinary underground copper mining the shafts, tunnels, drifts, hoisting and pumping engines, and hand

(Concluded on page 244.)

Quinine in the Treatment of Gaseous Gangrene*

With Notes on the Value of Quinine Hydrochloride as a General Antiseptic

By Kenneth Taylor, M.A., M.D.

In the course of experiments in the production and treatment of gaseous gangrene in laboratory animals, the following observations on quinine hydrochloride have been made. In view of their possible application to the treatment of clinical gaseous gangrene, and also of other infections, it seems advisable to publish them as a preliminary note pending further investigations.

Since the activity of the bacillus aerogenes capsulatus of Welch (frequently termed "perfringens") seemed to be due to or associated with an active ferment elaborated by the growing organisms, quinine was selected on account of its antiferment action as being likely to show an inhibitory effect upon the growth of this bacillus.

Preliminary experiments on the action of varying concentrations of quinine hydrochloride upon the growth and gas production of the bacillus in dextrose broth were undertaken. It was found that growth and gas production were consistently inhibited when the quinine concentration in the fermentation tube reached 0.075 per cent. Similar experiments with the growth of the bacillus in the deep agar medium gave the point of concentration at which inhibition occurred as varying between 0.100 per cent and 0.125 per cent. A third experiment was then undertaken, the medium tested being a thick pus recovered from a case of empyema which contained the bacillus aerogenes capsulatus, the colon bacillus, and the bacillus pyocyaneus. In this menstruum it was found that the B. aerogenes capsulatus was killed after exposure for ten hours to a concentration of 0.100 per cent of quinine hydrochloride. The colon bacillus was killed after exposure for a similar period to a concentration of 0.225 per cent. The B. pyocyaneus still grew after exposure for a similar period to a concentration of 0.500 per cent.

With a view to establishing some sort of a standard of bactericidal value for the quinine solution a parallel series of tubes of dextrose broth inoculated with B. aerogenes capsulatus were treated with quinine or carbolic acid in varying amounts. In this series it was again found that the bacillus was repeatedly inhibited by a concentration of 0.075 per cent of quinine, while it continued to grow and form gas in a concentration of 1.900 per cent of carbolic acid.

In order further to determine the relative values of quinine and of carbolic acid in the sterilization of pus, two different types of pus were used as menstrua and the following tests were made.

Pus A, obtained from necropsy in a case of empyema and lung abscess, was very thick and contained an admixture of bacteria to which was added a heavy inoculation of the B. aerogenes capsulatus. The pus then contained the latter bacillus, the colon bacillus, streptococci, and the B. pyocyaneus. Out of a series of six tubes containing 5 cubic centimeters each of the pus, five were treated with varying percentages of quinine and carbolic acid; the sixth was reserved for control. They were examined at intervals of 10 minutes, 1 hour, 4 hours, and 24 hours. At these intervals heavy inoculations of the contents of each tube were made into nutrient media.

The following charts give the graphic representation of the results obtained as regards (1) B. aerogenes capsulatus, and (2) other bacteria.

The series of experiments on Pus B was run in a similar manner, but with slightly different concentrations of the antibacterial agents. The pus in this case, also obtained from empyema, was of thinner consistency and contained streptococci, to which was added gas bacillus. The results were again charted and growth recorded (1) for the gas bacillus, and (2) for the streptococcus.

It will be seen from examination of the charts that quinine caused the disappearance of the gas bacillus at a point of concentration at which carbolic acid was completely ineffectual. In concentrations of carbolic acid higher than those charted the gas bacillus has survived longer than any of the other organisms in either specimen of pus. It has grown and formed gas even after an exposure for 24 hours to a concentration of more than 1 per cent. In the case of quinine, however, the gas bacillus has usually been the first to disappear from mixed pus in the weaker concentrations. The colon bacillus has usually followed closely; the B. pyocyaneus has generally been the most resistant. It will also be seen that quinine has been more effective than carbolic acid against the other bacteria in the pus.

Chart I.—*Growth of B. Aerogenes Capsulatus after Exposure to Equal Concentrations of Quinine Hydrochloride or of Carbolic Acid for Different Lengths of Time.* *Pus A.*

Chart II.—*Growth of Bacteria other than B. Aerogenes Capsulatus after Exposure to Equal Concentrations of Quinine Hydrochloride or of Carbolic Acid for Different Lengths of Time.* *Pus A.*

Concentration.	Chart I. Quinine.						Chart I. Carbolic Acid.						Chart II. Quinine.						Chart II. Carbolic Acid.					
	Control.	% .075	% .20	% .37	% .50	% .75	Control.	% .075	% .20	% .37	% .50	% .75	Control.	% .075	% .20	% .37	% .50	% .75	Control.	% .075	% .20	% .37	% .50	% .75
After 10 minutes......	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
" 1 hour.........	G	G	G	G			G	G	G	G	G	G	G	G	G	G			G	G	G	G	G	G
" 4 hours........	G						G	G	G	G		G	G	G			G		G	G	G	G	G	G
" 24 hours........	G	?					G	G	G	G	G		G	G					G	G	G	G	G	G

G = Growth on Reinoculation. ? = Result in Doubt.

On the basis of these demonstrations of the efficiency of quinine against the gas bacillus, the following experiments on its use in the prophylaxis and treatment of experimental gaseous gangrene were undertaken. The animals used were full-grown guinea-pigs; the cultures were two strains of the B. aerogenes capsulatus; one obtained in pure culture from the heart's blood at the necropsy of a patient dying from the infection, the other obtained in pure culture from the blood of a living patient suffering from extensive gaseous gangrene of the thigh. The two strains proved equally virulent, invariably killing a 500-gramme or 600-gramme guinea-pig after injection of $\frac{1}{4}$ cubic centimeter of a 24-hour broth culture. The necropsy findings were characteristic, showing extensive muscle degeneration, formation of gas, and, later, bloody subcutaneous exudate. The bacillus could nearly always be recovered from the heart's blood at death. The following is a list of the experiments in the order undertaken:

Laboratory Experiments

Experiment 1.—Six guinea-pigs, all inoculated in the thigh with ¼ cubic centimeter of 24-hour broth culture. Two were reserved as controls. Four were treated, two of them by immediate injection of 1 cubic centimeter of 2.5 per cent quinine hydrochloride solution, the other two similarly injected half an hour after inoculation. Both controls died within 18 hours. Three of the four treated recovered. The other died at 36 hours, having lived twice as long as the controls.

Experiment 2.—Five guinea-pigs, inoculated in the thigh with the same dosage (¼ cubic centimeter). Two were reserved as controls. Three were treated by injections into the muscles with 1 cubic centimeter of quinine hydrochloride about 15 minutes after inoculation. The controls died within 18 hours. Two of the treated guinea-pigs recovered. The other died at 42 hours.

Experiment 3.—Six guinea-pigs, inoculated in the thigh with the same dosage (¼ cubic centimeter). Two were reserved as controls. Four were treated after half an hour by injection of 1 cubic centimeter of 2.5 per cent quinine hydrochloride solution at the site of inoculation. The controls died, one at 24 hours, one at 48 hours. One of the four treated recovered. The others died at about 30 hours.

Experiment 4.—Four guinea-pigs, injected subcutaneously with the same dosage (¼ cubic centimeter). Two were reserved for controls. The other two were injected after 15 minutes with 1 cubic centimeter of 2.5 per cent quinine hydrochloride solution in the same region as the inoculation. The controls died within 18 hours. One of the treated pigs failed to develop the disease. The infection progressed in the other and it died after 42 hours.

Experiment 5.—Four guinea-pigs, inoculated into the muscles of the thigh with the same dosage (¼ cubic centimeter). Two were reserved as controls. Two were treated by injection of quinine into the affected thigh 6 hours after inoculation. The controls died at 48 and 72 hours, respectively. The two treated pigs recovered.

Experiment 6.—Four guinea-pigs. Two controls were inoculated in the thigh with the usual dosage of the bacillus. The other two were injected in the thigh with 1 cubic centimeter of 2.5 per cent quinine hydrochloride, and half an hour later were inoculated in the same thigh with the same dosage of the bacillus that the controls had received. All four were killed 18 hours later and the legs examined. The treated animals showed a slight infective process. In the untreated controls the gangrene had progressed to a point of considerable muscle necrosis.

Experiment 7.—Four guinea-pigs were anæsthetized and after the removal of a portion of the skin a punctured wound was made in the muscle of the thigh with a capillary pipette. The wound was injected with the usual dosage of the bacillus. The wounds of the two reserved as controls were then irrigated with normal salt solution. The wounds of the other two were irrigated with a 2.5 per cent solution of quinine hydrochloride. The controls died within 56 hours. One of the treated animals recovered.

Experiment 8.—Five guinea-pigs were anæsthetized. A portion of skin was removed from the thigh and a punctured wound was made in the muscle with a capillary pipette. The wounds were then injected with 1/20 cubic centimeter of the bacillus. Three reserved as controls were irrigated with a normal salt solution; the other two were irrigated with 1 cubic centimeter of 2.5 per cent quinine hydrochloride solution. The three controls died within 18 hours. The two treated animals died about 10 hours later.

Experiment 9.—Five guinea-pigs were anæsthetized. A portion of skin and a section of muscle were removed from the thigh, making a wound in the muscle about 5 millimeters deep by 2 millimeters in diameter. 1/20 cubic centimeter of the culture of the bacillus was instilled into the wound. After half an hour the wounds of the two reserved for controls were washed thoroughly with 2 cubic centimeters of normal salt solution. The wounds of the other three were washed with an equal amount of 2.5 per cent quinine hydrochloride. One of the controls died within 12 hours. The other developed gaseous gangrene of the thigh, from which it is still suf-

Chart I.—*Growth of B. Aerogenes Capsulatus after Exposure to Equal Concentrations of Quinine Hydrochloride or of Carbolic Acid for Different Lengths of Time.* *Pus B.*

Chart II.—*Growth of Streptococcus after Exposure to Equal Concentration of Quinine Hydrochloride or of Carbolic Acid for Different Lengths of Time.* *Pus B.*

Concentration.	Chart I. Quinine.						Chart I. Carbolic Acid.						Chart II. Quinine.						Chart II. Carbolic Acid.					
	Control.	% .025	% .050	% .075	% .125	% .250	Control.	% .025	% .050	% .075	% .125	% .250	Control.	% .025	% .050	% .075	% .12	% .25	Control.	% .025	% .050	% .075	% .125	% .25
After 10 min....	G	G	G	G	G	?	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
1 hour...	G	G	G	G			G	G	G		G	G	G	G	G	G			G	G	G		G	G
4 hours .	G						G	G	G	G	G	G	G					G	G	G	G	G	G	G
24 hours .	G						G	G	G	G	G	G	G						G	G	G	G	G	G

G = Growth on Reinoculation. ? = Result in Doubt.

* From *The Lancet.*

ering. The three wounds treated with quinine solution healed cleanly, without discharge or sign of infection, and the animals are now completely recovered.

Three additional experiments were performed:

A.—Four guinea-pigs, inoculated in the thigh with the usual dosage, were killed at intervals of 1, 2, 4, and 6 hours after inoculation. The infected thighs were found to show gaseous distension of the muscle sheaths and softening of the muscle after two hours. The cases healed must, therefore, be regarded as representing a more advanced stage of the infection than the time after inoculation would appear to indicate.

B.—With a view of determining the local toxicity of quinine injection varying amounts of a 2.5 per cent solution were injected into the muscles of the thigh, the animals killed at varying intervals, and the tissues examined. No macroscopic pathological effect could be demonstrated.

C.—In order to determine the possible inhibition by quinine of the tryptic degeneration of discharges from the wounds (to which is attributed by Sir Almroth Wright the alterations or "corruption" of these discharges from an anti-bacterial substance into a suitable medium for bacterial growth), the concentration of quinine required to prevent tryptic digestion of egg albumen was further investigated. It was found that no digestion occurred in solutions in which the quinine concentration reached 0.37 per cent. The concentration which was used in the foregoing expriments has in all cases been 2.5 per cent.

The results of the animal experiments are grouped in the following table:

Untreated.			Treated with Quinine Hydrochloride.					
Number.	Number died.	Mortality per cent.	Number.	Number died.	Mortality per cent.	Recovered.	Recovered per cent.	Recovered or improved.
20	20	100	22	9	41	13	59	82%

SUMMARY.

It will be seen that whereas all the 20 untreated animals died (100 per cent), only 9 of the 22 animals (41 per cent) receiving quinine died from the infection, while several other treated animals which eventually died were evidently temporarily benefited by the treatment, as manifested by the extended duration of life above that of the control. It may be noted that the usual course of the fatal infection following intramuscular inoculation has been under 30 hours.

CONCLUSION.

The results of the observations may be briefly summarized as follows:

A.—Quinine has shown a marked bactericidal activity against the gas bacillus. 1. It has inhibited its growth *in vitro*, where it was ten times as effective as carbolic acid. 2. It has reduced the mortality from gaseous gangrene in animals from 100 per cent to 41 per cent.

B.—Quinine has shown strong laboratory evidence of value as a general antiseptic. 1. Its general bactericidal power was higher than that of carbolic acid. It was especially effective in a menstruum of pus. 2. It did not damage healthy tissue in local injections of effective concentrations. It is known to produce local anæsthesia, frequently a desirable result. 3. It produced no symptoms of intoxication in the animals treated. It was used in hypertonic solution. 4. It showed a strong antitryptic action *in vitro*.

Upon the evidence of these experiments a 1 per cent solution of quinine hydrochloride is now being tried in some of the wards at this hospital for the treatment of gaseous gangrene and other infections. (At the time the above article was written, it is evident that no attempt had been made to apply the treatment in actual practice. Since then, however, reports have been published to the effect that one of the nurses attached to the hospital intentionally inoculated herself with cultures of the bacilli, and was successfully treated by the new method. Editor.)

The Uses of Intense Heat

And Some of Its Applications to Industrial Processes

From an engineering point of view intense heat can be used for carrying out many industrial processes to which at present other means are applied. It is true the commercial man does not always see eye to eye with the man with scientific knowledge, and many a process which may not only be possible but may actually seem to be advantageous in theory may prove in practice to be too expensive to be carried out commercially. But there have been many industrial applications of high temperature which have proved financially sound.

Ordinary fuel furnaces can seldom be raised to a high temperature, but oxy-hydrogen and oxy-acetylene furnaces are capable of giving out great heat. Extremely high temperatures, sufficient to deal with even the most refractory substances, can be obtained in the electric furnace, and by certain chemical reactions temperatures approaching the highest of which the electric furnace is capable can be obtained at a comparatively low cost.

Nitrogen, which is the largest constituent of atmospheric air, is partly responsible for the fact that combustion furnaces cannot produce such high temperatures as the chemical and electrical furnaces. It has a restraining influence on the flame, and prevents an excess of oxygen from reaching the combustible material. It has been found that the nitrogen can be driven from its association with oxygen in the air, and a device has been made in which the nitrogen is literally whirled away. This consists of a drum fitted with fixed vanes on its inside circumference, the outside shell being perforated. Air is forced through this while it is revolving at a high speed. The heavier constituent of the air is driven outward by centrifugal force, and as the intake is drawn from the center of the drum a greater quantity of oxygen passes to the furnace than would otherwise be the case. In a factory where an adaptation of this idea was tried commercially it was found that the same amount of steam could be raised as before with a saving of 27 per cent of the coal bill.

ELECTRIC FURNACE PRODUCTS.

The electric furnaces now in use can be broadly divided under the headings of resistance, arc, and induction furnaces. Those of the first type are used principally for the production of pig iron. The stack is filled with a mixture of ore, coke, and flux, and a heavy current is passed through the mixture, with the result that a chemical reaction takes place as soon as the temperature is sufficiently high and the iron flows, the various impurities floating on the surface in the form of slag. In the arc furnaces, used for many purposes, the substance to be treated is placed between two suitably disposed electrodes across which an arc is struck. In the induction type a special form of crucible is used, which, with its contents, becomes the secondary of an induction coil, through the primary of which a heavy alternating current is passed. In this arrangement the resistance opposed by the crucible and its contents to the passage of this induced current raises the temperature of the furnace to a degree which is limited only by the supply of energy or the current-carrying capacity of the primary.

Although the electric furnace is being so largely employed in the steel and iron industries, it is used for producing many substances which, before its introduction, were either unobtainable or only procurable with difficulty and at great cost. One of its latest products is silundum, or silicified carbon, which was first formed by heating carbon in an atmosphere of silicon. Its most valuable property is its ability to withstand a high temperature without oxidizing, and it is used as a resisting material for various electrical purposes.

Metallic mercury is now obtained by heating its sulphide, or cinnabar, in an electric furnace. It is said that this method does not possess the defects of earlier processes. The furnace is placed under a hood through which a constant current of air passes, and the ends of the electrodes, which project outside the furnace, are placed within closed tubes, so that no vapor may escape. The mercury vapor which is the result of the distillation condenses in a suitable condenser. The charge consists of a mixture of cinnabar and lime, twice as much of the latter being used as there is mercury in the ore. Should the amount of lime be insufficient, it is interesting to note that the vapor of metallic mercury is accompanied by that of the sulphide.

Carborundum, a product of the electric furnace, is largely used as an abrasive in machine tool work, but grinding wheels are now being made from aloxite, an abrasive obtained by smelting kaolin, carbon, and oxide of iron in a furnace of the resistance type. Aloxite may be considered as being principally fused aluminium silicate.

Calcium carbide is another product of the electric furnace, and it may be mentioned that in the manufacture of this substance it has been shown that the resistance type of furnace is superior to all others. In recent tests the best result obtained with the arc furnace was 1,170 watt-hours per 100 grammes of pure carbide, while with the resistance type the same quantity of pure carbide was obtained with 544 watt-hours.

Furnaces taking exceptionally large currents have been introduced of recent years, with electrodes carrying 40,000 amperes and upward at from 75 to 90 volts. In a three-phase furnace this would mean a total load of upward of 12,000 horse-power. For the manufacture of carbide double tri-phase furnaces have been laid down with a load capacity of upward of 18,000 kilowatts, equal roughly to 24,000 horse-power.

FIXATION OF NITROGEN.

Mention must also be made of the use of intense heat in the manufacture of nitric acid from the air. Nitric oxide is formed by the high temperature of an electric arc, but unless the oxide is removed immediately it has formed, it breaks up again into its constituents. It is thus necessary to stop the arc immediately it has formed, remove the oxide, and re-strike the arc. There are many methods of doing this, which are somewhat complicated by the fact that to produce nitric acid on a commercial scale it is necessary for the arc to be as long as possible so as to expose a sufficient amount of air to its influence. In one form of furnace the electrodes curve upward and outward, and the arc, which is struck at the bottom, is rapidly blown upward until it reaches a point where it becomes too attenuated and breaks. The air blast which forced it up the electrode removes the formed acid, and, by an automatic arrangement, the moment the arc breaks at the top of the electrodes it is reformed at the bottom.

FUSION OF QUARTZ.

One of the most interesting and industrially useful processes for which a high temperature is necessary is the fusing of quartz, which, when brought to a fluid state by means of an oxy-hydrogen blowpipe, is molded into flasks, bowls, tubes, and other vessels which are used for chemical purposes and for domestic applications of electricity, cooking utensils, and so on. They are unaffected by acids or alkalis, and are practically indestructible, except through willful damage, and they may be raised to a temperature many hundreds of degrees beyond that to which glass can be heated, and at that temperature may be dropped into cold water without injury. Quartz is now being used in many types of electric heating and cooking appliances.

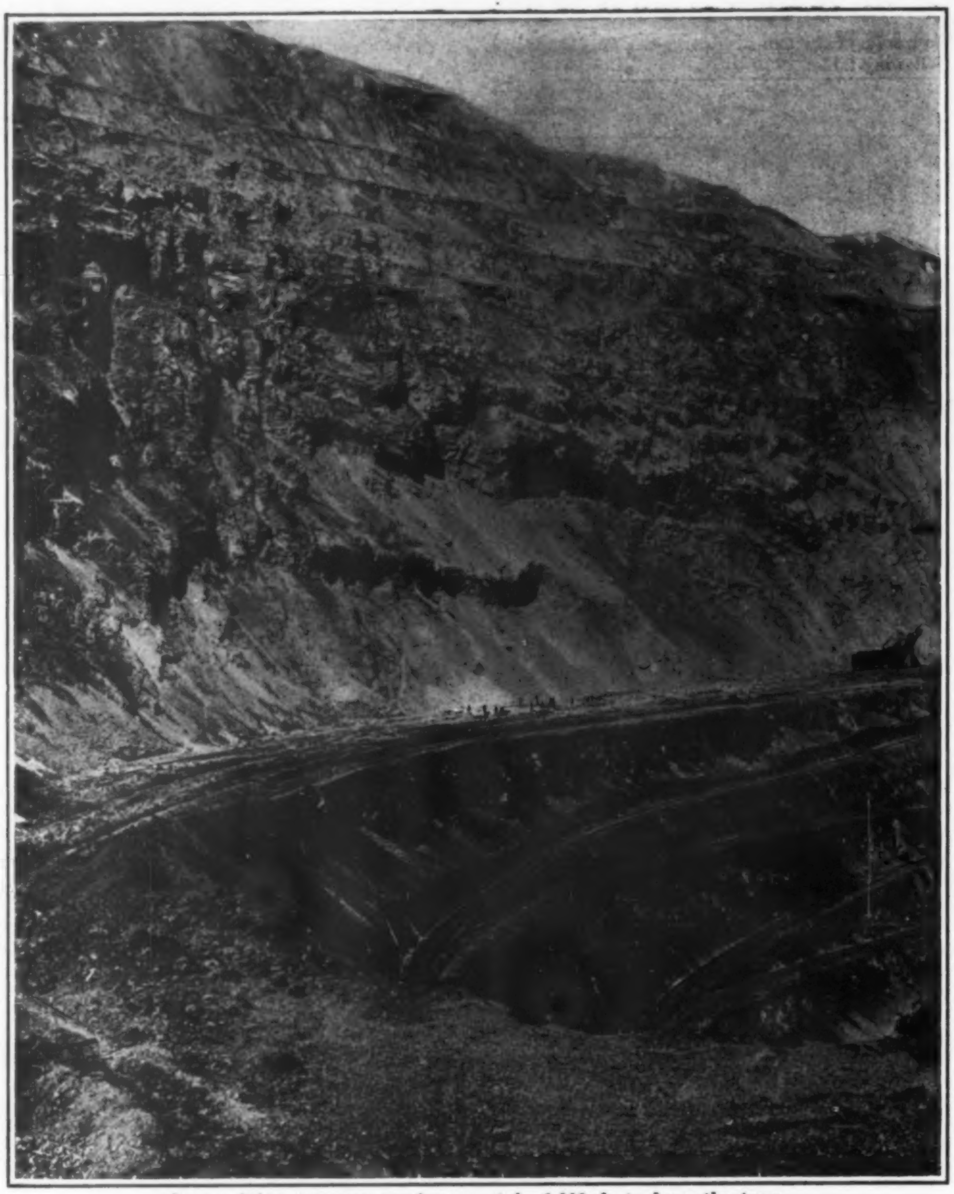
ELECTRIC LIGHTING.

Every form of electric light is produced by the formation of intense heat by the passage of an electric current through a resisting body. Thus the metal filament lamp consists of a filament of tungsten or tantalum, metals which oppose considerable resistance when hot to electricity. The work done in overcoming this resistance produces so much heat that the temperature of the filament becomes so high that the metal is raised to a white heat. The higher the temperature to which the metal can be raised without melting or volatilizing, the higher is the efficiency of the electric lamp in which it is used. For that reason experiments have been carried out for some time past with the rare metals with the object of finding one from which filaments of higher efficiency than those of tungsten can be made.

The light of an arc lamp, again, is caused by a stream of white hot carbon or carbon and metal particles issuing from what may be likened to a miniature lake of white hot molten carbon, and the stream of vaporized mercury, heated to an almost incredible degree by a current of electricity, is the source of the light given by the lamp which is known by the name of its conducting material.

CHEMICAL WELDING.

The proneness of aluminium to oxidize is well known, and indeed no metal has a stronger affinity for oxygen. Use is made of this affinity in an industrial process for repairing fractures in metal bodies. Finely powdered aluminium, mixed with equally finely powdered oxide of iron, is placed on the broken part, a mold is built round it, and a small quantity of magnesium wire or filings is placed on the top of the heap. This fires immediately when lighted, and the topmost layer of aluminium at once seizes the oxygen in the iron and is immediately raised to an extremely


Open mining terraces on the mountain 1,000 feet above the town

high temperature. In the fractional part of a second the mold is full of a bubbling, coruscating mass of molten iron, which flows round the broken parts and welds them together. Several fractures in heavy material, such as could have been repaired in no other way, have been put right by this process, and castings weighing over nine tons have been dealt with. As in everything else, there is an element of uncertainty about the process, and there have been a number of failures, due either to improper use of the material or to an obscure form of crystallization which is at times set up by the temperature, which approaches 4,000 deg. Cent. in the parts immediately surrounding the fracture.

Recently oxy-acetylene welding has been made use of to a large extent in construction and repair work, both the high and low pressure systems being employed. The temperature of the flame produced is about 6,000 deg. Fahr., and in theory 2.5 volumes of oxygen are required to one of acetylene. In practice it is usual, however, to use a larger amount of acetylene, and volumes of 1.4 to 1.0 are customary. The proportions have only been brought to this low mark during the past three years or so, the reduction being due to the fact that commercial oxygen is now much purer than was formerly the case. Unless a very pure carbide is used and all ammonia and other impurities removed from the acetylene, there is considerable risk of spoiling a weld. The process is largely employed in the large tube works, and in motor-car work. The majority of branch exhaust pipes from cylinders are now welded in this way, and chassis frames can be welded up instead of being riveted. Repairs to cylinders or frames can also be carried out without difficulty. Ship boilers are peculiarly liable to corrosion, and badly corroded boilers until recently had to be scrapped; but now, by the oxy-acetylene blowpipe, metal can be run into the corroded parts and the plates brought back to their original thickness. Corroded hull plates can also be built up to their former strength.—*Engineering Supplement of the London Times.*

A Mining Camp Without a Peer

(Continued from first page.)

shoveling bring the cost up to 10 or 12 cents per pound under the best organizations. All these are eliminated at Bingham. There are no shafts or tunnels driven; no hoisting or pumping. All is open-mining, and gigantic steam shovels do the work of the mucker and his pick.

Ten years ago this mine was practically abandoned. Since the new managing engineer took charge and put new methods into operation, the stockholders have received in dividends $25,000,000, and as much more has been earned and put into permanent development and equipment.

This typical mine, up to the year 1900, had been operated for the lead, silver and gold, but that became exhausted, and the copper ore was of too ridiculously low grade to show, then, any possibility of anything but loss. Then came an engineer from Missouri, D. C. Jackling, who has made a lifelong practice of changing "I want to be shown" into "I'll show you."

He looked over the mountain of copper ore; tested the surface and explored the abandoned tunnels and drifts. Then he went to the old stockholders and said: "There's copper there in enormous quantities; hundreds of thousands of tons. You've got through with the silver-lead ore; now work on the copper!"

"Yes, we know," they jeered. "It's there, all right, and what are you going to do about it? Two per cent ore! It won't pay for the picks and shovels used. No man has ever paid cost on less than six per cent ore! Run away and play at something else, Jackling."

He did so. He ran over to New York and Boston, and by his startlingly original proposition of open mining interested some big capitalists. He came back, bought up those old mines at old song figures, and formed a new company. He requisitioned no picks or shovels; put no men into shafts and tunnels; set up no hoisting engines or pumps. Instead, he brought in rails and locomotives and giant steam shovels. He commenced stripping off the four-foot surface of gravel and clay, got down to the porphyry ore and set his big shovels to work on that. That was the first open metal mining in the United States and to-day it is the greatest in the world.

Two immense crushing and concentrating mills to treat the ore have been built; the most audacious and costly twenty-mile industrial railroad in America to carry the ore to the mills; sixty miles of tracks have been laid on terraces round that fifteen-hundred-foot high mountain, on which are operated a score of powerful locomotives, hundreds of steel cars, a dozen gigantic steam shovels, and many quick-acting power drills.

Across the Salt Lake Valley, twenty miles from the canyon, farmers and villagers are awakened each morning by the terrific blasts on that mountain. Over three tons of dynamite or other explosives are used between the changes of the night and day shifts, and the same quantity each evening.

During the past year or two a trip to the Bingham Canyon is something that few tourists through Salt Lake miss. A twenty-mile ride to Garfield takes them to the gigantic smelter and the equally big crushing mills. Another twenty-five miles over the company's private railroad, plunging between the giant peaks of the range, some of them perpetually snow-covered; crossing deep, weird canyons, climbing appaling grades and curves so sharp that the engineer and conductor of a long train of ore cars may be traveling east and west respectively, but both going up.

You reach the terminus at Bingham, 600 feet above the one-street town of 3,500 population, straggling for over a mile along the narrow, crooked bed of the canyon.


One of the mills at Bingham, reached by a two-mile tunnel under the mountain.

Beyond is the mountain, its twenty terraces dotted with machines and men. They are blasting out and shoveling up and hauling away 70,000 tons of ore and waste every twenty-four hours, 25,000 tons of which is millable ore and is freighted to the crushing mills and smelters at Garfield, where the daily reduction results in 200 ounces of gold, 2,000 ounces of silver, and 400,000 pounds of copper, with an aggregate value of $75,000.

And, in spite of that great sequestration of ore, men who have worked here for the past ten years say that scarcely any diminution in the size of that mountain can be observed. Another giant mass of ore and silicates is close by and is now getting its preparatory stripping.

During the year just passed the company has had engineers making deep borings and scientific and exhaustive tests to determine the quantity of that ore yet unworked. Their report is that an excess of 340,000,000 tons of millable ore is in those mountains, waiting to be used. At the present enormous rate of operation, that quantity will keep the 3,000 employees busy for another half century, but the company's plans, already perfected but delayed just now by the great war, will quickly double the capacity of all the apparatus and mills. Then of a certainty the dust will fly as never before.

That is only one mine of the Bingham Camp, although it is by far the greatest. The others are chiefly engaged in getting out lead and zinc, with a small percentage of silver and gold. The figures for 1913 are:

Gold		$1,774,815
Silver	Ounces	2,408,692
Lead	Tons	35,500
Zinc	Tons	1,711

Up in the several cross canyons leading out of Bingham are the crushing mills of these mines and one or two smelters. One of the groups is in such an inaccessible location that a two-mile tunnel has just been finished to afford transportation for the ore to the outer world. With others the ore is freighted in buckets on aerial cableways across and around the wild rugged peaks and canyons.

The power used is chiefly electricity transmitted across the Salt Lake Valley from power-houses on the mountain torrents of the Wasatch Range.

Filtering Oil in the Power Plant

Methods Adopted Where High-Speed Machinery is Used

The machinery of a modern power plant usually runs at a high speed, and the lubrication, especially where great powers are developed, is generally on the forced feed principle, with large quantities of oil running continuously through the bearings. Naturally oil used in this way is not exhausted, as to its lubricating qualities, by a single passage through the bearings, and it can be used over again a number of times if the proper precautions are taken to free it from any foreign matters that it may take up in its passage.

Particular attention has been given to the filtering of oil in such plants, and quite elaborate apparatus has been devised for the purpose that is performing excellent work. One such apparatus was described recently in *Power*, to which publication we are indebted for the description and illustrations.

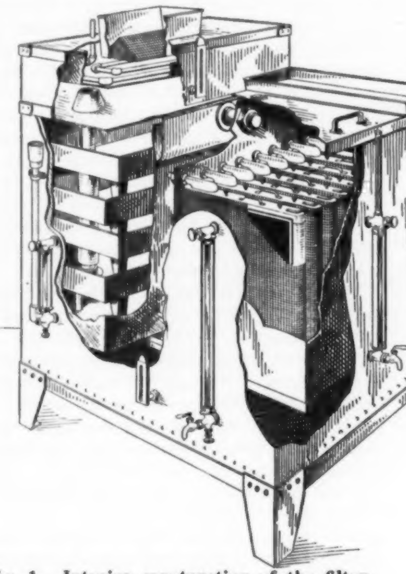


Fig. 1.—Interior construction of the filter.

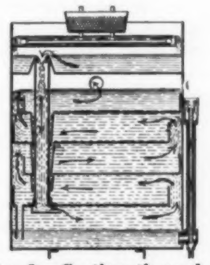


Fig. 2.—Section through water-separating chamber.

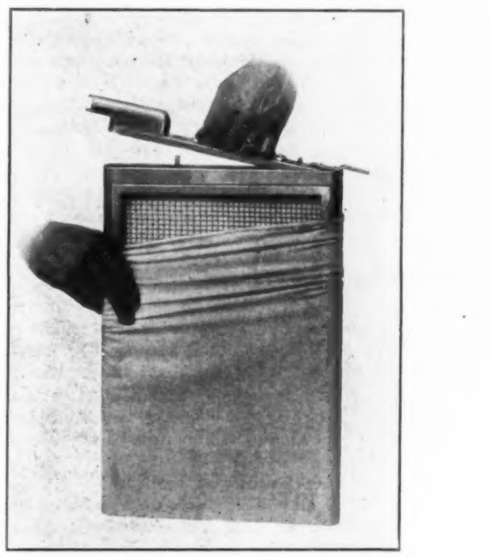


Fig. 3.—Non-collapsible filtering unit.

The dirty oil enters through the strainer box at the top and passes down through the removable strainer, where large particles of foreign matter, such as waste and the like, are strained out; the oil then goes to the heating tray where its viscosity is reduced. It then flows to the compartment below the heating coils and down through the funnel. The further operation of the precipitation compartment is more clearly shown in Fig. 2.

Passing down through the tube conductor, the oil is spread out by a baffle under the lower tray. Under the action of the greater head, which builds up in the tube conductor, the oil is forced to take a zigzag path upward, passing under and over several trays, as shown by the lines of flow. It then passes out through the opening below the heating tray to the filtering compartment. The separated water collects in the bottoms of the different trays and is bypassed to the bottom of the precipitation compartment by means of funnels that surround the tube conductor, and does not again come in contact with the traveling oil.

The water which is removed by the precipitation process is automatically ejected by an overflow tube at the right, which consists of two concentric pipes. The water flows upward through the outer tube and spills over the top of the funnel. The lower end of the tube can be connected to a sump or sewer. The funnel is threaded and can be raised or lowered, providing for proper adjustment for oils of different specific gravities. This water overflow simply operates on the U-tube principle; that is, the column of water in the outer pipe balances a column in the filter made up partly of oil and partly of water. As oil is lighter than water, the top of the overflow is a little lower than the level of oil in the precipitation compartment. As more water is precipitated out of the oil, the water level in the precipitation compartment tends to rise and the leg of the U-tube, which is inside the filter, becomes heavier because it is made up of a greater proportion of water and less of oil. Thus water flows over the top of the funnel until the two legs of the U-tube again balance. In this way a low-water level is automatically maintained in the precipitation compartment.

Referring to Fig. 1, the level of the oil in the top tray is maintained constant by the skimmer, and the oil then flows through a pipe into the filtering compartment, which contains nine non-collapsible filtering units, such as is shown in Fig. 3. The oil passes from the outside to the inside of the filtering units, then out through the nozzles which project through the wall of the filtering compartment, to the clean-oil compartment. The nozzles on each unit fit into a spring-actuated valve so that any individual unit can be withdrawn and cleaned without interfering with the continuous operation of the filter. When the unit is withdrawn, this valve closes and prevents unfiltered oil from flowing into the clean-oil compartment. The filtering cloth is so arranged that it is free from folds or plaits, thus rendering every square inch active in filtering.

No oil can pass to the clean-oil compartment until the level in the filtering compartment reaches the outlets. Thus no filtering takes place until every square inch of cloth is submerged in oil; then as soon as a slight head builds up over the outlet, the process of filtration begins and is distributed over all of the surface, which is subjected to equal pressure.

The head of oil over the filtering disks is shown by an indicator at the top of the gage. When the filter is being operated at normal rating this gage should show a level of about three inches. If a greater height is indicated it shows that the oil is not passing through the cloth as fast as it should and that the cloths need cleaning. The filters are rated at 3-inch head over the filtering disks, but space is provided for carrying a 6-inch head. Thus the apparatus is capable of handling short overloads of 100 per cent, so that in case a large batch of oil should be run in, the filter will be able to take care of it.

The advantage in arranging the filtering cloth in a vertical position and having the oil pass from the outside to the inside of the units is that the slime and sediment which collect on the cloth continually work toward the bottom and drop off, thus automatically tending to keep the surface clean. The filtering medium is a special grade of cloth that does not act as a screen, but actually filters the oil largely by capillary action.

The water level in the precipitation compartment should be carried as low as practical. The gage shows the clean-oil level. The cock on the fitting at the bottom of this gage provides for withdrawal of clean oil to use in cans for hand oiling. The right-hand gage shows the level of the oil in the filtering compartment. This should at all times be full of oil.

All of the level gages have sheet-metal guards in back of them, which are white enamel on the inside. This makes it easy to see at a distance the oil level and also protects the glass from breakage.

A thermometer shows the temperature of the oil before it enters the precipitation compartment, thus enabling the engineer to adjust the quantity of heat supplied so that the proper viscosity will be maintained. Another thermometer shows the temperature of the oil in the clean-oil storage compartment.

The filter body is constructed of galvanized sheet steel, reinforced with channel and angle iron. All joints are lapped and closely riveted and soldered.

The only parts needing periodical cleaning are the filter cloths. The filtering units can be easily removed without interfering with the continuous operation of the filter and should be lifted out and set in a pan of kerosene or gasoline and brushed down with a stiff brush; this is possible because all the sediment collects on the outside of the cloth. Occasionally, the cloths can be removed and washed in gasoline or kerosene to thoroughly clean them.

The filter is built on the unit principle, and has been constructed with a capacity of 7,500 gallons per hour in a single unit.

Condensation of Gasoline from Natural Gas

Those gases containing the higher paraffin hydrocarbons are, of course, of greater heating value, and some of them may be used for the extraction of gasoline. About 24,000,000 gallons of gasoline was made from such natural gas in 1913.

Natural History of the Whale Shark—II*

Facts About a Monster Fish That Is Little Known

By Prof. E. W. Gudger, Ph.D.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2075, Page 233, October 9, 1915

IN the *Zoologischer Anzeiger*, 1901, Kamakichi Kishinouye of the Imperial Fisheries Bureau, Tokyo, Japan, gives a description of what he makes out to be a new species of *Rhineodon*. However, Dr. Gill (1902) thinks it *R. typus*. Omitting the description of the teeth the following is the interesting account of this fish given by the Japanese ichthyologist, while Figs. 7 and 8 are lateral and frontal views copied from his paper:

"On the 10th of June, 1901, a rare and gigantic shark was caught by drift net off Cape Inubo. Mr. Tsuratame Oseko who keeps a collection of rare things for show in Asakusa Park, Tokyo, bought the fish and brought its skin to Tokyo to be stuffed, notwithstanding many difficulties accompanying its enormous size and ponderous weight. The external part is complete, except the portion between the anal fin and the caudal.

"The general appearance of the fish is very ugly, with the flat and blunt head, straight, terminal mouth and the small eyes. The skin is fine-grained, except five longitudinal smooth bands, one dorsal median and two pairs lateral. The ventral lateral band seems to be continuous to the keel on each side of the tail (Fig. 1).

"The eye is very small, situated at the sides of the head near the margin of the colored portion of the head. The nictitating membrane wanting. The spiracles are nearly the same in size and are on the same level with the eyes. The nostrils are at the anterior extremity of the head. They open at the labial boundary of the mouth.

"The mouth is nearly straight and opens at the anterior extremity of the head, too. A labial fold from the nostril to the corner of the mouth on the upper jaw and a shorter one from the corner of the mouth on the lower jaw. (Fig. 2.)

"The gill openings are five in number and are very wide. The second pair is widest and measures 86 cubic meters. The last pair is most narrow, it opens above the base of the pectoral fins, where the body is very broad and high. The pectoral fins are large and long. The first dorsal fin is inserted a little behind the middle of the body. The second dorsal fin is very small. The ventral fins are inserted below the first dorsal. The clasper is simple, with a dorsal groove. The anal fin is very small. It is just below the second dorsal. The caudal fin is large and lunate. Its ventral lobe is well developed.

"The color is greyish-brown, with white round spots and transverse bands, but the ventral side is colorless. The white round spots are small and crowded near the anterior end of the body, but become gradually larger and fewer backward. The caudal fin, the second dorsal, the ventrals and the anal, are destitute of white markings.

"The stuffed animal now measures 800 centimeters in length and 365 centimeters in circumference, behind the pectorals. Mr. Oseko tells me that the skin has shrunk much and that the fish measured nearly 1,000 centimeters when fresh. He says, moreover, that the shark was covered with many sucking fishes and one of these fishes and a pole made of oak (ca. 30 centimeters long) were found in the stomach.

"Though the hitherto-known allied species (*Rhineodon typicus* Smith and *Micristodus punctatus* Gill) are described insufficiently, I am inclined to believe that this fish is a new species of the *genus Rhinodon*, as it differs from these species in the form of teeth and the labial fold. Hence, I propose the name of *Rhinodon pentalineatus* for this species."

Jordan and Fowler (1903) list this shark in their "Elasmobranchiate Fishes of Japan" on the basis of Kishinouye's description.

On page 88 of his *Introduction et Description de l'Expedition* (Siboga), Max Weber (1902) records the fact that, while in the strait between Buton and Muna, Celebes Islands, East Indies, several examples of the Whale Shark were seen but none could be captured.

In his description of the fishes of this expedition (vol. 57 of *Siboga Expeditie*, p. 594), Weber says that these gigantic sharks swam around the vessel so closely that they were easily recognizable, but that, when an effort was made to capture them, they sank out of sight.

In *Science* for February 28th, 1902, Mr. B. A. Bean, Assistant Curator of Fishes in the United States National Museum, records the stranding on the shore near Ormond, Florida, of an 18-foot specimen of *Rhineodon typus*. This is the first record of the occurrence of this rare shark on the eastern coast of America, and, in fact, its first known occurrence in the Atlantic Ocean. Its skin is now among the treasures preserved in the National Museum at Washington.

In the issue of *Science* for May 23rd, 1902, there appeared an exceedingly interesting article entitled "The Whale Shark (*Rhinodon typicus*) as an American Fish," from the facile pen of Dr. Theodore Gill. In this, Dr. Gill gives a valuable resumé of a good portion of the known references to this rare fish, and concludes by conjecturing that the American forms may possibly be of a distinct species entitled *Rhineodon punctatus*.

Bridge (1904), in *The Cambridge Natural History*, Vol. VII, on page 454, gives a very general account of the *Rhinodontidae*, but adds practically nothing to our knowledge.

Again in *Science* under date of May 19th, 1905, Dr. Gill summarizes some additional data bearing especially on the habits of the Whale Shark which he here calls *Rhineodon typus*. I take occasion here to acknowledge my indebtedness to these two articles of Dr. Gill and for data which he gave me personally.

A few weeks after the appearance of Dr. Gill's last note, Mr. Barton A. Bean published his valuable *History of the Whale Shark* in Smithsonian Miscellaneous Collections. This paper, giving a considerable number of verbatim quotations and being finely illustrated, has been of much help in the preparation of this article.[7]

In his paper Mr. Bean gives careful measurements of the Ormond, Florida, specimen, he also gives a careful description of the teeth. The skin of this 18-foot specimen was a dark brownish-grey, while the carinations were of a light chocolate color. The spots on the body were comparatively few, but large, while on the head they were smaller but in much greater numbers. The transverse light-colored bands were absent, strange to say, though probably they had faded out of the dried skin. Underneath the body was light colored. Fig. 1 is the elegant frontispiece to Mr. Bean's paper.

In the same year (1905) Jordan's *Guide to the Study of Fishes* appeared. On page 540 of Vol. I, there is a paragraph given to the *Rhinodontidæ*, but there is no new data whatever.

In 1908, Lloyd records the capture of a small specimen at the mouth of the Hooghly River at the head of the Bay of Bengal in 26½ fathoms of water. This fish was 14 feet long, 4 feet wide across the nose and 3½ feet across the mouth. The girth around the head was 8½ feet, and around the belly 9½. Its color was a "dark bluish-grey with large irregular paler blotches." The small teeth were in bands in each jaw, 350 rows of about 10 teeth to each row in a band, or about 7,000 in all.

The occurrence of *Rhineodon* in the Java Sea is recorded by Van Kampen in 1908. On May 7th, fishermen harpooned in Batavia Bay and brought to the fish market in Batavia a specimen 5.75 meters long (about nineteen feet). Van Kampen dissected this specimen but gives no account whatever of its internal organs.

Weber (1913) relates that Van Kampen showed him a beautiful photograph of a specimen which he thinks was probably caught in Madura Strait (north coast of Java) and photographed while fresh in the harbor of Surabaia. Unfortunately Van Kampen does not seem to have written up this specimen.

Dr. H. M. Smith in 1909, in an interesting paper entitled "Some Giant Fish of the Seas," gives only general data but a fine picture of the Whale Shark in the act of diving. Two years later, before the Biological Society of Washington, he made known the occurrence of this fish in the Philippine waters.

In the issue of the *Philippine Free Press* of September 10th, 1910, there is published a photograph with brief description of a marine monster from one of the islands, Negros Occidental by name. Throughout the article, the animal is called a whale, but the photograph shows it to be a Whale Shark. It was about eighteen feet in length and was caught in a fish trap near Bacolod on September 4th, 1910. This is the first capture, so far as known, that has been made in the waters of our western possessions.

Through the kindness of Col. C. R. M. O'Brien, C. M. G., governor of the Seychelles, and of Mr. P. R. Dupont, Curator of the Botanical Station at Mahe, I have received information (December 8th, 1914), that the "chagrin" is very common about the Seychelles throughout the year. Mr. Dupont writes that he has come across several himself, that the fishermen report that the smallest seen measures about 20 feet long, and that they come in shore when shoals of a Caranx make their appearance.

This huge but very rare fish, so far from having a restricted distribution, has an extraordinarily wide one. While found in the Atlantic, and not altogether infrequent in the Pacific, its especial habitat seems to be in the Indian Ocean and the waters contiguous thereto.

JAWS AND TEETH.

The jaws are enormously large, the teeth almost microscopically small. Smith, the discoverer of the fish, says in his first paper (1829): "Teeth short, gently curved, so disposed in longitudinal rows that they have the form of a band in the front part of the maxilla, and likewise in the similar part of the mandible."

Müller and Henle were the first scientists to examine Smith's specimen after its deposit in the Museum of Paris. Of it, they say (1841): "Teeth extraordinarily small, conical, very numerous, card-like in arrangement. The conical teeth, with points somewhat curved backward, were in a 15½-foot specimen scarcely a line (1-12 inch) long. They stand in 12 to 15 rows, one behind another, about 250 to a row." Their figure of the teeth is given herein as number 10. This is from their plate 35, which also contains a semi-diagrammatic section of the tooth band. This contains fourteen rows, each having 19 teeth. Fourteen rows with 250 teeth to a row would give a total to each jaw of 3,500 teeth; if fifteen rows, then 3,750 teeth. Later it will be shown that both their description and their figure of the teeth are alike erroneous.

In his fuller paper (1849) Smith merely says: "Teeth, small, recurved, closely congregated, and disposed in a broad, transverse belt along the inner surface of each jaw, immediately inside the lips."

In 1865, August Duméril after examining the Table Bay specimen gives as the characters of the family *Rhinodontidae*:

"Teeth exceedingly small and very numerous, analogous to the teeth of a card which are very fine and bent backward, and comparable to the brush-like teeth of certain teleosts, forming a band rough to the touch on each of the jaws on which the band is interrupted in the regions of the median line."

While under the heading, *R. typicus*, he thus specifies: "The band of teeth is formed by 12 or 15 transverse rows of teeth, having a width of about 0 m. 0 3. In a square of 0 m. 0 3. on each side are found 17 teeth in 12 rows each or 204 teeth. Now the two jaw bands form together, deduction being made for the median spaces, a length of one meter (.45 above, and .55 below), 33 squares of 0 m. 0 3. on each side, or 33 times 204 equals to at least 6,732 teeth. This number is considerably larger than that given by Müller and Henle, who counted 12 to 15 rows of 250 teeth each, a number evidently too small, and who got only 3,750 teeth" (in each jaw, a point Duméril overlooked).

Dr. Gill, in the same year (1865), in writing of the form from the gulf of California, says:

"The dried dentigerous band of the upper jaw is slightly curved forward, about 19 inches between the extremities, and somewhat more than an inch in width in front. The teeth are fixed and extremely minute, the largest being little more than a line in length, and decrease toward the end of the jaw; they are disposed in regularly transverse rows, of which there are over one hundred and sixty (164–167) on each side, while in front there are from thirteen to sixteen in each transverse row; each tooth is recurved backward and acutely pointed, swollen and with a heel-like projection in front rising from its base."

How accurate is Dr. Gill's description may be judged from the accompanying Fig. 11 of the teeth of this specimen which is here copied from Mr. Bean's 1905 paper.

Wright speaks of the Seychelles "Chagrin" as having "a mouth of immense width, furnished with small teeth." Here it will be well to recall Buist's statement that the Kurrachee specimens had mouths 4 feet wide, while that of Haly's Ceylon fish was 3 feet across. Of the teeth, Haly writes(1883):

"When fresh, the lower jaw was quite straight and flat, nearly, if not quite, on a level with the surface of the abdomen, and considerably in advance of the upper, so that the band of teeth in the lower jaw was quite uncovered. This band averages one inch in breadth (in

* Abstracts from "Zoologica," Vol. 1, No. 19, published by the New York Zoological Society. Cuts by courtesy of the Society.

[7] To the officials of the Smithsonian Institution I am deeply indebted, not merely for permission to copy the figures in Mr. Bean's paper, but for the use of the blocks themselves.

a 23-foot, 9-inch specimen), and consists of 14 rows of minute, sharp, recurved teeth, 2 millimeters long, all of equal size. The band in the upper jaw is three quarters of an inch broad, and consists of 11 rows of similar teeth.

Nation sent a portion of the jaw of the Callao specimen to the British Museum. This was examined by Günther and the teeth compared with those of Ward's specimen from the Seychelles. Günther writes (1884): "The teeth differ in no respect from those of a Seychelles Chagrin; they are conical, sharply pointed, recurved, with the base of attachment swollen." This is the first detailed description of the teeth of *R. typus*, and so like Gill's account of the dental armature of *Micristodus punctatus* that Günther unhesitatingly declares them to be identical. (Here see Fig. 11.)

Thurston says of the specimen in the Colombo Museum: "Each jaw is armed with a band of teeth arranged in regular transverse rows (14 in the lower jaw), and so minute that, in the present specimen their number has been calculated to be about 6,000."

Kishinouye thus described the dental apparatus of his specimen:

"The teeth are very minute and numerous. They are nearly equal in size and shape. Each tooth is acutely pointed, laterally compressed, and with an ellipsoidal root. The band of teeth on the upper jaw is curved a little and at each end of the band there is a detached group of teeth. The band on the lower jaw is crescent shaped. In each band the teeth are arranged in a great many transverse rows, about 300 in number. In the middle part of the band we count 16–30 teeth in one row."

Bean says that the teeth of his Florida specimen are, "— in lower jaw in fourteen longitudinal rows; in upper jaw there are thirteen longitudinal and about three hundred vertical rows of developed teeth." His figure of the upper jaw of the Ormond specimen is given herein as Fig. 12, while Fig. 13 is a magnified view of three of these teeth.

Last of all Lloyd found the teeth in his specimen to be small, numerous, recurved, in bands in each jaw. Each band had about 350 rows of teeth with about 10 teeth in each row, making approximately 7,000 in all.

INTERNAL ORGANS.

This shark has been dissected by Smith (1849), by Wright (1870), by Haly (1883) and recently by Van Kampen (1908). Unfortunately, however, none of these authors, save Smith, gives any account of the internal organs.

"Pharynx very large and the inner extremity of each branchial canal obstructed by a sieve-like apparatus, consisting of a congeries of cartilaginous tubes closely set together, directed laterally, and the inner extremity of each fringed with a delicate membrane offering an obstruction to the passage of anything but fluid. Oesophagus rather narrow, and at its commencement bends downward toward the parietes of the abdomen, and forms nearly a right angle with the fauces, which gives the fish the power of completely preventing what enters its large mouth from being admitted into its stomach, unless desirable. The cardiac extremity of the stomach is very muscular, and the inner surface is studded with hard pointed nipple-like bodies, all of which are directed backward, and offer an obstacle to the return of anything solid from the stomach: the rest of the inner surface of the stomach and the small intestines closely set with strong rugæ, in the stomach oblique, in the intestines nearly circular; and the latter, when about to terminate in the large intestines is also furnished with a number of nipple-like bodies, which prevent solids from passing downward. The termination of the small intestine is in the form of a ring which projects into the large bowel and forms an effective valve when any attempt is made to propel the contents of the large intestine backward into the smaller. The inner surface of the former is furnished as in other sharks with a spiral band, the one side of which is loose, and by this arrangement the alimentary fluid requires to pass over an extent of surface sufficient to permit of the necessary absorption of the nutritive portion of the ingesta. The rectum, internally, is quite smooth, and the gland which, in sharks generally, is situated behind it, also exists in this fish, and opens into the gut about six inches from the anus. On each side of the latter there is a large opening, through which a probe can be readily introduced into the cavity of the peritoneum, and into that cavity, it would appear, the sea water enters through these openings, as it contained about eight gallons perfectly pure, or at least only with some animal secretions.

"The liver consists of two lobes nearly of equal size, the length of each, 3½ feet; the greatest width, 13 inches, the least, 6 inches. The gall-bladder is exterior to the surface of the liver, and is situated on its concave or dorsal aspect, close to its base, before it divides into lobes. It is of a piriform shape, and the duct is much convoluted and so large as readily to admit the forefinger of a full-grown man; it discharges the bile into the upper extremity of the large intestines, and the point where it enters their outer coat is fully two inches higher than that at which it perforates the inner; the duct between these two points is contracted and tortuous, and the terminal opening is not larger than would admit a pea.

"The spleen is closely connected with the inferior extremity of the stomach and the hinder surface of the small intestine, and, excepting where it winds under the apex of the former, is lobulate, as in the true sharks, and exhibits a striking resemblance to the spleen of *Alopias vulpes*, Raf. The pancreas is slender, and partially encircles the upper extremity of the large intestine."

FOOD AND FEEDING.

Here we are dealing with the vertible giant of sharks —the Whale Shark, *Rhineodon typus*, whose measured length runs from fourteen to forty-five feet, and whose length estimated by men accustomed to such reckonings may reach the vast figure of seventy feet, but whose manner of life is even more peaceful than that of the common dog-fish. For, be it known, that this largest among fishes is not merely a whale in size, but in manner of feeding, its almost microscopic teeth being in consonance with the minute size of the animals on which it feeds.

Smith, in his first paper, (1829), gives no intimation of the food of this great fish, but in his later (1849) and fuller paper he goes into the matter at length.

"The stomach was empty, hence the precise food of the fish could not be ascertained. That a portion of it, at least, is derived from the mollusca, etc., which are taken into the mouth and pharynx, with the sea water which is required for the purifying of the blood, is to be inferred from the branchial openings being so guarded. That the fringes at the inner extremity of the tubes, which exist in the branchial canals, are for the purpose of intercepting such small animals as may be contained in the water, I infer from knowing that the whale (Balæna), which feeds on small mollusca, etc., has the inner edge of each layer of whale bone converted into a fine floating fringe, which permits the water taken into its huge mouth to escape, but intercepts all objects adapted for its food.

"When our shark proceeds to feed, the first step it probably takes is to open its jaws to their full extent, in order to permit the mouth and pharynx to become filled with sea water. On that being accomplished, the jaws are then probably closed in order that the water shall, by muscular efforts in the pharynx, be propelled through the tubes in the branchiæ, and forced thus to leave behind it whatever mollusca, etc., it may chance to contain. The powers of deglutition after this are probably called into action, and the oesophagus, no doubt, is raised and straightened, so as to offer a ready passage downward to whatever shall have been collected during the escape of the water. The mammillary eminences around the cardiac orifice of the stomach appear to indicate that some, at least, of the articles of food are swallowed alive, and that they require to be bruised and also prevented from re-entering the oesophagus, both of which are probably effected by the processes just mentioned. The direction taken by the upper part of the oesophagus is evidently for the purpose of enabling it the more effectively to resist the entrance of the water, when being expelled through the branchiæ by the muscular contraction of the pharynx."

The man of all others who has had the greatest opportunity to study the feeding and other habits, and who was guilty of the greatest error, was E. Perceval Wright. While at the Seychelles, just prior to 1870, he dissected at least two specimens, male and female. As to its food, here is what he says (1870):"—contrary to the general habits of the true sharks, it is not a carnivorous but a herbivorous fish." However, Steenstrup (1873),[8] having conclusively proved that the great Basking Shark, *Selache (Cetorhinus) maximus*, which had been thought to feed on algæ, is by virtue of its curious gill apparatus a feeder on small marine organisms, severely criticized Wright's theory of herbivorous feeding in *Rhineodon*. Wright, having satisfied himself by study of *Selache*, that this animal is a carnivore, in 1876, acknowledged his error in these words: "—I now have no doubt that both these big lubberly beasts—which in their mouths have scarcely more than the name of teeth—feed on all sorts of minute oceanic creatures, frequently taking in with them floating algæ."

Again in 1877, Wright says, and repeats the statement in his *Animal Life* (1879):

"I found large masses of algæ in their stomach, so that at one time I was inclined to think it was an herbivorous shark; probably, however, it derives its nourishment, in part, at least, from minute crustaceans and other oceanic animal forms which may be taken in along with masses of floating weed, and, then ejecting the water through the strange mesh-like structure that unite the edges of the great gill openings, obtain by so doing enough to swallow."

Haly (1883) merely notes that "the stomach contained a quantity of finely divided red matter." This was probably crustacean remains. While Gill (1905) clearly shows that its food consists of the plankton strained out of the water by its peculiar gill apparatus.

In the stomach of Kishinouye's Japanese specimen (1901), there was found a sucking fish and a fragment of an oak pole one foot in length. A number of sucking fish were found adhering to the shark when it was caught. Chierchia reports that several were adhering to the inside of the mouth of his specimen.

Van Kampen dissected a fair-sized specimen at Batavia, Java, and reports as follows: "In its stomach I found nothing save some sepia shells, and some small fish (*Gobies, Saurics*)."

HABITS.

The Whale Shark, which is in size the chiefest of the Selachians, has absolutely no offensive habits. Its huge bulk may inspire terror, but it is the quietest and most inoffensive of marine animals.

In defensive habits, *Rhineodon* seems likewise to be entirely lacking.

Beyond seeking to escape by slowly swimming away, this gigantic elasmobranch rarely makes any defense.

Even when taken in nets (Haly, Kishinouye) there is no evidence that it makes any serious defense. Undoubtedly, *Rhineodon typus* is the mildest mannered shark that swims the seas.

NAME.

At first (1829) Smith gave his great shark the name *Rhincodon typus*, but later (1849) changed it to the more common forms *Rhinodon typicus*.

In 1831, Bonaparte followed Smith in using the generic name *Rhincodon*. In 1838–1839 Swainson published the names *Rineodon*, *Rhineodon* and *Rhiniodon*. About the same time; Müller and Henle, at the conclusion of their visit to London made to collect data for their great forthcoming work on Selachians, published in the *Magazine of Natural History* and in *Archiv für Naturgeschichte* (1838) a preliminary paper in which they give the genus *Rhineodon*, but three years later (1841), when they published their great work on sharks and rays entitled *Systematische Beschreibung der Plagiostomen*, they gave this shark the name *Rhinodon typicus*, which has been the one commonly used ever since.

[8] Both Gill (1902) and Bean (1905) erroneously attributed this reference to Lutken.

NOTE:—Dr. David Starr Jordan, in *Science* for March 26th, 1915 (page 463), records the receipt from Mr. W. F. Cameron, a correspondent of his at Zamboanga, Philippine Islands, of a photograph of a 20-foot specimen of the Whale Shark, taken at the Island of Zebu. In its stomach were found a number of shoes, leggings, leather belts, etc., a most incongruous mass of stuff in reference to what we know of the feeding habits of this great shark. This adds another to our short list of specimens, and the second for the Philippines. E. W. G.

Destruction of Wasps

A CORRESPONDENT of the *Journal* of the Royal Society of Arts says:

"I have recently discovered (and I do not know if the fact is generally known) that the vapor of benzol and gasoline is quickly fatal to wasps and many other insects. Touched with a brush dipped in either spirit they instantly collapse and die.

"During the past few days I have destroyed three wasps' nests by the injection of about 2 ounces of gasoline into the nest by means of a small syringe. The first injection is sprayed over the mouth of the nest. This entirely prevents the escape of any of the insects, and kills the sentry wasps at once. The balance is sprayed right into the hole.

"One partly destroyed nest was laid open, and several hundred wasps were found, covering an area as large as a cheese plate. The first discharge of the syringe over these killed the lot, and not one escaped. The gas is not ignited in any way, but acts probably either by asphyxiation or by producing a fatal anesthetic effect.

"The method is so simple and easy of manipulation that I feel it cannot be too widely known, and as it involves the use of no dangerous or poisonous substance, is highly to be recommended where these pests abound."

New Method of Making Sulphuric Acid

A NEW method of manufacturing sulphuric acid, for which advantages are claimed, is suggested in United States Department of Agriculture *Bulletin* No. 283. The essential difference of the method is that the gases employed are drawn downward through a spiral flue in place of being drawn through lead chambers or intermediate towers. It is asserted that the resistance of gases to the downward pull and the constant change in their course through the spiral tend to mix them very intimately. The fact that the gases constantly impinge on the walls of the spiral flue, which can be cooled either by air or water, makes it practicable to maintain the gases at a temperature most favorable for the efficient yield of sulphuric acid.

In laboratory tests in which the spiral was utilized practically all the sulphur dioxid was oxidized to sulphuric acid, only traces being lost through escape or in the system. This device is, however, not intended to replace the Glover tower, nor to do away with the Gay-Lussac tower.

An Indiana Desert

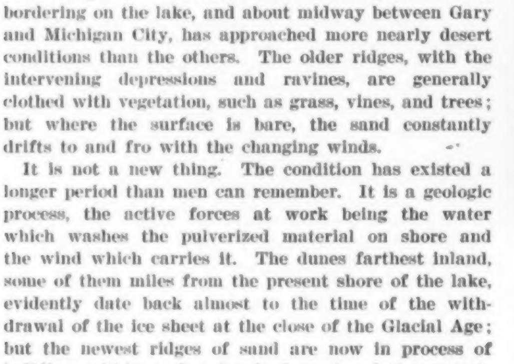
A Curious Region of Constantly Changing Character

By Hu Maxwell

It is not necessary to go to Africa to study desert phenomena, for Indiana has a genuine desert, though a small one. Few of the characteristic features are wanting, but it is necessary to observe some of them in miniature.

At the extreme southern end of Lake Michigan, along practically the whole coast between Gary and Michigan City, Indiana, a distance of twenty miles or more, the waves in time of storm have thrown immense quantities of sand on shore, and the wind has carried it inland and piled it in dunes and ridges, varying in height from a few feet to a hundred or more. The region of dunes extends south from a thousand yards in some places to several miles in others. A tract bordering on the lake, and about midway between Gary and Michigan City, has approached more nearly desert conditions than the others. The older ridges, with the intervening depressions and ravines, are generally clothed with vegetation, such as grass, vines, and trees; but where the surface is bare, the sand constantly drifts to and fro with the changing winds.

It is not a new thing. The condition has existed a longer period than men can remember. It is a geologic process, the active forces at work being the water which washes the pulverized material on shore and the wind which carries it. The dunes farthest inland, some of them miles from the present shore of the lake, evidently date back almost to the time of the withdrawal of the ice sheet at the close of the Glacial Age; but the newest ridges of sand are now in process of building within a few hundred yards of the water's edge.



An abatis made by wind-driven sand.
An uprooted jack pine's branches and roots have been sheared off and the stubs have been whittled to bayonet-like points by blasts of sand carried by the wind.

There is no question that Lake Michigan's southern margin was at one time several miles south of its present location; but whether the retreat of the water was due to the northward tilting of the lake basin, or to the accumulation of sand, or to both causes combined, is not particularly important in considering the present desert-like condition prevailing in some parts of the dune region.

The sand which is here deposited from ten to one hundred feet deep over many thousands of acres, is peculiarly soft and delicate. It has none of that harsh glass-and-iron feeling usually belonging to sand thrown up by the ocean. In climbing the barren slopes, one's shoes are soon filled, but the sensation suggests shoes filled with flour rather than with sand. The material is finely ground sedimentary rock, mixed with such soil and silt as brooks and rivers carry into the lake, or as is washed from the face of bluffs far up the lake. Waves roll upon the shore with remarkable violence, because the north wind, when storms are high, strike land here after a clear sweep of three hundred miles over the water. Breakers wash a hundred yards upon the beach, and there deposit their loads of detritus, which speedily becomes the building material for dunes. The ridges, therefore, immediately after being thrown up, possess such fertility that vegetation secures a foothold in a few years after the sand ceases to drift; but the areas where desert conditions prevail are those in which the sand is constantly moving.

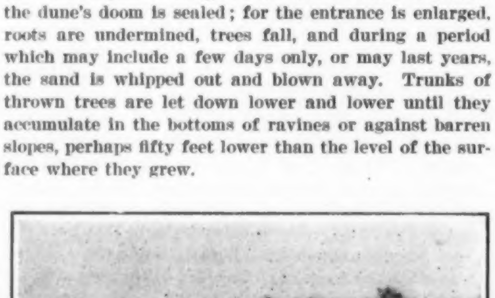
LIVING AND DEAD DUNES COMPARED.

It is the active dune which presents the picture of death; but when it really dies and becomes stationary, it is speedily clothed with vegetation, and its aspect is pleasing enough. The active heaps and ridges are those which are either forming or disappearing. Change may take place very slowly or it may be remarkably rapid. Anything which disturbs the wind currents plays havoc with the contour of adjacent tracts, leveling them in one place and elevating them in another.

Jack Pines push to the front.
This is an old dune which has long been at rest. Thin humus supports a scant vegetation. A typical jack pine, eight inches in diameter and thirty feet high, occupies the center of the stage. The ground is covered with wild rye, while bur oaks, forty years old and three inches through, betray the soil's sterility.

Steam shovels, loading sand trains, have disturbed the balance of forces at considerable distances from the actual operations, and the winds are diverted into new routes, where in a short time they scoop out thousands of tons of sand, and, massing it in places which had been undisturbed for years, bury whatever happens to be there. The attack with steam shovels, however, is only a local and temporary cause of change. Centuries before civilized man set foot in the region, building and destruction were in progress; ridges were piled up to be blown away later; vegetation flourished and was overwhelmed. The evidence of this is seen on all sides, proving that what is going on to-day has been in progress for a long time.

Old ridges which had been at rest so long that trees are growing on them, are caught in some freak wind's course, and distruction begins. If the foliage is dense and the roots matted, the wind may be unable to make a successful direct attack on the crests of the elevations; but the assault is none the less successful in the end, and destruction is sure. No military engineer ever sapped and mined a besieged place more persistently. A weak spot in the vegetable covering is found somewhere on the slopes of the ridges or at the bottom, and the wind begins to scoop out the sand. From that hour the dune's doom is sealed; for the entrance is enlarged, roots are undermined, trees fall, and during a period which may include a few days only, or may last years, the sand is whipped out and blown away. Trunks of thrown trees are let down lower and lower until they accumulate in the bottoms of ravines or against barren slopes, perhaps fifty feet lower than the level of the surface where they grew.



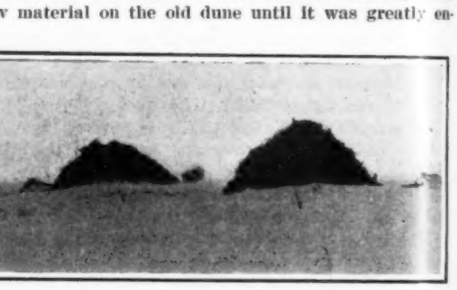
The work of two weeks.
Fourteen days before this photograph was made, not an ounce of sand was visible in the area. It is now twenty feet deep on the right, and in its forward movement it is rapidly burying everything in its course. The work of a steam shovel, a quarter of a mile away, deflected the wind currents and produced the change.

WORK OF THE SAND BLAST.

The abrading power of the driving sand is remarkable, even though in the mass it is so soft as to resemble flour. Every minute particle that strikes a surface seems to cut. The trunks of fallen trees, which happen to lie where the blast is fiercest, show the savagery of the attack. The wood is worn and eaten away, and the surface is polished to the smoothness of glass by the streams of passing sand. The limbs of prostrate pines are amputated by the sharp grains that are driven by, and the stubs remaining fast to the trunks are whittled to sharp points, resembling abatis constructed to destroy charging cavalry.

Sometimes the weak things of earth are chosen to confound the mighty. This is illustrated in the Indiana desert. The wind and sand overthrow and utterly destroy pine trees, but the wildgrape vine may offer successful resistance, and protect the portion of the dune one which it grows. It spreads over the surface, forming of tendrils and leaves a circular mat fifteen or twenty feet in diameter. The wind cannot undermine these small patches here and there, but blows away the sand and lowers its surface between them. Mounds covered by the vines are gradually formed, rising from six to ten feet above its surrounding surface, and from a distance looking like haystacks in a snowy field.

Most of the old dunes are graveyards where standing trees were buried years or centuries ago. A common method seems to have been followed in most cases. A low ridge remained at rest long enough for trees to grow on it. A change in the wind routes then deposited new material on the old dune until it was greatly enlarged, and its forests were buried as they stood. Again a period of rest brought new growth, which, in its turn, was buried under fresh accumulations. In some parts of the area there is evidence that four or five forests, one above another, were successively buried, with the trunks all standing. The trees usually die soon after the drift accumulates a few feet deep around their bases; and if the building goes on slowly, tops decay and break from the dead trunks, so that snags and high stumps only are buried. Once securely beneath the surface, decay ceases, and the stubs remain embalmed in sand until they are brought to light long after, when the burial mound is blown away, exposing superimposed tiers of stumps, with an occasional branchless, barkless trunk standing full length.



Mounds protected by wild grape vines.
Wind is carrying the sand away from this area. Two clumps of sprawling vines have protected the sand beneath them, and it remains in the form of mounds, while the surrounding ground surface has been lowered from five to ten feet. The change is slow here.

WHAT THE EXCAVATIONS REVEAL.

The principal kinds of trees uncovered when the mounds and ridges are excavated by the wind or the dredge, are the same as grow now in the undisturbed areas. The jack pine (*Pinus divaricata*) is the prevailing softwood. A few white pines (*Pinus strobus*) are still met with, but they were evidently more plentiful a century or more ago than at this time. For their present scarcity the lumbermen of seventy-five years ago was doubtless responsible; for the tall, straight trunk of this pine was tempting. Among the wrecks exposed by the removal of forty feet of sand are white pines large enough for sawlogs. A stub twenty-six inches in diameter, with the roots attached, was the largest measured. It lies on or near the original surface of the land at the close of the Ice Age, as seems probable from the fact that at the same horizon and not many rods distant, a granite glacial boulder is exposed to view. The drifting sand could not have moved the boulder; so, it must lie now where the ice dropped it at the close of the Glacial Age. It is an erratic, because there is no native granite anywhere in the region. It may have been carried all the way from Canada. The sand which

was piled high over it fifty years ago is all gone now. Construction trains removed some of it, and wind blew the rest away.

An occasional log or stump of red cedar (*Juniperus virginiana*) comes to light where the dunes are cut down by wind or shovel. This species yet grows in the region, but sparingly and of small size. A whip-like specimen, fifteen feet high and two inches in diameter, stands defiantly in perpetual motion on the apex of one of the sharpest, highest pinnacles of sand, swaying so violently in the wind at all times as to defeat attempts to photograph it, except with a camera quick enough to snap a flying humming bird.

Among other trees which grew here in past centuries, as the excavated remains bear witness, were cottonwood (*Populus deltoides*), basswood (*Tilia americana*), white elm (*Ulumus americana*), and several oaks, the most common being bur oak (*Quercus macrocarpa*) whose habit of growing in unfriendly situations was featured in James Fennimore Cooper's novel "Oak Openings."

HOW VEGETATION STARTS.

The chief matter of interest connected with this Indiana desert is not so much what grew here in the past, and was buried by drifting sands, as what now grows, and how it obtains a start and is able to maintain its foothold. This refers to trees and other perennials, the very existence of which presupposes fixedness and stability of soil. Their advent into life, their growth, death, burial, and excavation may be studied side by side, and often in very small areas. An incident will show how uncertain the tenure of plant life is among the dunes. Two visits were made to the locality, a period of fourteen days intervening. At the first visit a certain plot of an acre or more was observed on a gentle slope of an old dune. The place was at rest. There was no indication that a grain of sand had drifted there in fifty years. Young trees, from five to twenty feet high, covered the tract. Three small trees attracted particular attention, because they were so close together and were laden with fruit, which was then green, but would be edible when ripe. One was a wild black cherry (*Prunus serotina*), one a nannyberry (*Viburnum prunifolium*) and one a serviceberry (*Amelanchier canadensis*). The occasion is rare indeed when these three species may be seen growing side by side, and the fact that they were so growing in a place so unkindly as the slope of a sand dune, was sufficient to attract interest to that phase of ecology.

At the return visit two weeks later a somewhat difficult climb was made across a sliding slope in order to see the same trio of little trees again. A profound change had taken place. It was at first difficult to recognize the spot. The trees and all their near associates had vanished. The sand had taken a turn in that direction and had buried them, and at that moment it was pouring down the newly formed slope and was rapidly burying the young oak and sassafrasses lower down.

Far from its native home.

Steam shovels after years of work have uncovered this glacial boulder which apparently rests on the original surface left by the retreating ice, probably 20,000 years ago. It is granite, such as is found northward in Wisconsin and Canada. Hundreds of acres in the neighborhood of the boulder have been cleared of sand to make railroad embankments in the vicinity of Chicago.

In other parts of the desert area two weeks sufficed to change many features of the topography. The suddenly increased activity was apparently caused by new attacks of the steam shovel on the ridges near the lake, but so far away that the connection between cause and effect was difficult to explain. The deflection of a single air current there appears to disturb a hundred currents and change the whole system of winds which circle round and over the dunes. Every change in the wind produces changes in the contour of the barren tracts. Sharp-crested ridges become rounded; steep slopes are modified; peaks quickly shoot up where none were before. When the surface is dry and the winds are strong, a surprising quantity of sand is on the move, but it seldom rises in the air more than a few inches, and is apt to escape observation, unless a watch

"The Saffron silk of Cactus Bloom."

In some spots coarse grass clothes the ground with an understory of cactus, bristling with thorns scarcely more than microscopic in size. The cactus, which was in bloom when the picture was made, is weak-stalked and procumbent. It may be easily removed by thrusting the hand into the sand beneath the mass of thread-like roots and lifting them out, stalk and all.

is kept where it passes over a sharp ridge. To leeward of a crest over which it has passed, it fills the air like a cloud, then drops to the surface and slides down the slope under the stress of gravity until friction brings it to rest.

Different kinds of vegetation take possession of the barren sand in different ways. It might be supposed that the needleleaf trees, like pines and cedars, would secure a footing first, since they are able to grow in situations so adverse that most broadleaf trees cannot maintain themselves, but that is not the order of succession here. Cottonwood, elm and basswood spring up against the sides of naked dunes, or on the very summit of peaks fifty or one hundred feet high. The seeds are carried there by the wind and dropped on the bare sand. It might be expected that they would inevitably perish, and doubtless thousands die to one that germinates; but a few seedlings spring up, strike root deeply in the sand, and if not buried or undermined, they grow with fair vigor. A slope of four or five acres may have only two or three seedlings to the acre, or there may be thickets of a few square rods. If the area remains at rest for a number of years, it becomes fairly well covered with weeds and brushes.

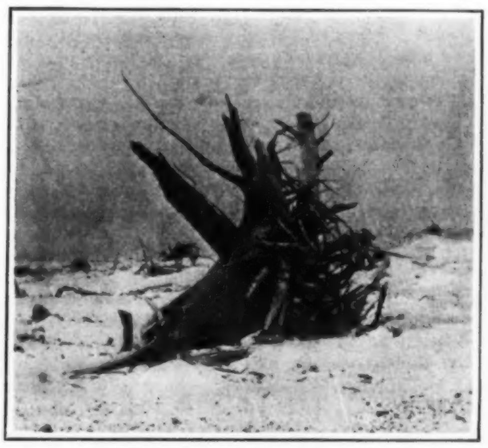
A fungus was found near the granite boulder previously mentioned, and was such a freak that it was worth attention. The top was protruding from the sand, in shape and size resembling half a cocoanut. When the sand was scraped away the root of the fungus was found anchored in a buried bur oak log a few inches below the surface. The fungus seemed to be a puffball, probably of the lycoperdon genus, species undetermined; but the interesting point is that it was petrified, if that term may be applied to a body which has changed to sand, the grains of which are loosely cemented together. When removed from the log the weight was found to be approximately that of stone. Efforts to bring it away that it might be identified and more closely examined were defeated. It broke while being handled preparatory to photographing it, and it soon crumbled. The explanation of the freak seems to be that the fungus, while growing beneath the surface of the ground, was unable to push the sand aside, as a tree's roots do, but occluded it; and when decay had removed the vegetable part, the sand skeleton remained.

The jack pine, mention of which has been already made, is the prevailing softwood of the region. It is a small tree, the average size being only large poles. Some people hold it in contempt and regard it as a nuisance. It deserves no such reputation. If one studies the little, thin foliaged tree, it will gradually win its way into his affection, until it seems to possess almost a human interest. It dies young, as the ages of trees are usually rated; for its span of life is about the same as man's. The hold which this tree has on the thin soiled hills of Northern Indiana is remarkable, because of the fact that it there reaches the extreme southern limit of its habitat. There lies the absolute outpost of the tree's frontier. Its range stretches from Yukon Territory to Nova Scotia. It laps slightly into New England, but for some reason its most southerly extension is in the Lake States, following down both the eastern and western shores of Lake Michigan, and it fringes, like a narrow ribbon, the lake's southern coast, and there its range in that direction terminates. If the theory is true, which some hold, that tree species followed the retreating ice sheet northward, it would place the origin of the jack pine near the southern end of Lake Michigan, from which point it spread to the Arctic circle. In that case, it did not come southward at all, but simply remained in its original home, and spread in a wide, fan-shaped range to Great Bear Lake in the northwest and the Bay of Fundy in the northeast. It looks so much like the sand pine (*Pinus clausa*) of Florida, that a somewhat careful observation would be necessary to distinguish one from the other, if they grew side by side; yet the ranges of the two trees are a thousand miles apart at their nearest approach.

The jack pine dies standing. Storms may throw the living trees, but not often. Those who have observed it in its more northern home, along the high shores of Lake Superior and among the rocky hills of Ontario, have been impressed with the melancholy landscape where dead jack pines, broken topped, limbless poles, stand whistling in the wind. The same habit is seen on Indiana's dunes. Unless undermined by the wind, it seems never to fall until decay causes it to break in pieces and the wind blows most of it away as dust. This pine is slow to take possession of newly formed sand ridges. Almost every other tree that grows there at all, pushes in ahead of it. Apparently its seeds, which must be present in the sand nearly all the time, will not germinate until the surface becomes somewhat shaded by a growth of wild rye, weeds, and brush. In summer the naked sand is too hot for its seedlings.

SOME HARD LUCK PLANTS.

At the different periods of their existence the dunes support other interesting vegetation. Nature takes peculiar care of some of the steep slopes while in process of building. A species of tall, coarse grass, with roots deep beneath the surface, grows with strong stalks and few blades. The stalks act as pegs to fix the steep incline and prevent small slides from breaking away from the slope and slipping to the bottom. Architects have learned a lesson from that provision of nature. They stud a steep roof with pins three or four inches long to hinder snow from sliding off and falling on persons below. Gardeners who set turf on terraces, pin the sod fast with pegs, just as the stiff grass stalks fix the sand.



A remnant of a former age.

An uprooted white pine snag twenty-six inches in diameter has been brought to light by steam shovels after removing thousands of tons of sand under which it was buried in the unrecorded past. The wood has been little affected by decay and still retains the characteristic white pine odor.

The plant more typical of deserts than any other is cactus. There are species enough to supply something special for every desert in America. Indiana's arid area was not overlooked in the distribution, though the cactus found there is not peculiar to that region. Its bristling thorns, though small as hairs, are as sharp as those of the fiercest fish-hook cactus of Arizona. The unloved plant makes itself welcome in its Indiana home. It grows rapidly, bears delicate yellow flowers, and pro-

duces fruit. It is probably of the species *Opuntia vulgaris*, akin to the devil tongues which have made the valley of the Rio Grande famous. It is not the earliest comer on the sand of the southern shore of Lake Michigan, but belongs to the jack pine period. It does not take to the naked tracts, but bides its time. On some of the old dunes, which have long been at rest, the cactus carpets the ground under the scrub oaks, and its thorns are so adroitly concealed by wild strawberry vines and wild rye that the person who incautiously reaches for the tempting berries, may erroneously conclude that he has picked a yellow jacket.

Cactus is not the only fantastic plant appearing on the sterile wastes. A venerable though diminutive representative of the Carboniferous Age thrusts its chrome-green, leafless stem, a few inches above the ground, but only in a few excessively sterile spots, and in depressions where so much of the sand has been removed as to bring the level down nearly or quite to the old ground surface before the invasion of the sand from the lake. The plant is one of the equisetums or horsetails, perhaps *equisetum hyemale*. Its ancestors of some millions of years ago were trees, and their ribbed trunks contributed enormously to the formation of coal. The specimens growing in the Indiana desert are scarcely a foot high; but, in all things except size, they look as their ancestors looked millions of years ago, if palobotanists have correctly pictured them. Their stems are covered with minute deposits of silica; so much is this so, that when a plant is crushed in the hand it feels like sand.

Nothing peculiar in the way of animal life attracts attention in the barren areas; for the tracts are too small to exercise much influence on things that move from place to place; but an interesting struggle for existence was observed on one particular spot, a miniature oasis in the center of the worst desert tract of all. At the lowest point of a sort of amphitheater, practically surrounded by hills of sand from fifty to ninety feet high, and so hot that in walking over the slopes one's feet seemed ready to roast in spite of heavy shoes, the water, in times of rain, runs to one place from several acres, and there soaks in the sand. The surface embracing a few square rods is damp. An army of tiger beetles, one hundred or more, had taken possession of the damp space and were running to and fro with such swiftness that the eye could not follow an individual far. They were preying on gnats, flies, and mosquitoes, which were evidently attracted by the coolness of the wet sand. So swift are the tiger beetle's movements that when he starts in pursuit, the unfortunate quarry is doomed. The murderous insects had learned in some way that hunting was good in that miniature oasis of the Indiana desert, where he had found a home.

Prophets who claim ability to see into the future, are certain that the most sterile tract of the sandy wastes, lying ten or twelve miles east of Gary, is destined to become the largest stockyard in the world. This will happen, it is said, when the Chicago yards will find it necessary to remove from the city to this site. It is not a new idea, but has persisted for a long time. Twenty-year old maps of northern Indiana give the metes and bounds of the "stock yards," occupying five quarter sections of land where the highest and barest sand hills still rear their crests. Steam shovels are at work, and have been for a score of years, eating their way through the dunes; and though they have cleared large tracts, no man now living will see the task completed.

Aeroplane Engines*

A Discussion of the Requisites and Details of Design

By Neil MacCoull, Jr.

THERE are three prime requisites for a good aeroplane engine: reliability, small weight per horse-power, and low fuel and oil consumption. Since these requirements are more or less conflicting, a compromise is necessary and the designer is confronted by the delicate question: Which of these is the most important? German designers with their customary thoroughness have produced more reliable but, generally speaking, heavier engines than those of England and France. For military work, this has proved a weak point because the lighter and hence faster aeroplanes can easily secure positions of advantage over their enemies', which usually makes it possible to bring them down. For all non-military service, however, except racing, reliability is unquestionably the fundamental requirement.

The balance between weight and fuel economy will be fixed by the particular service required, for the matter of importance is not the engine weight only, but the total weight of the engine and fuel. This is easily appreciated when one realizes that the fuel required for a flight of six or seven hours weighs as much as the engine itself. For short flights during which but little fuel is used, an exceptionally light engine is desirable, for the poor economy usually characteristic of such an engine is not very important. However, as the length of flight increases, economy becomes more and more important.

Other requisites which must not be overlooked, though they are by no means as important as those just mentioned, are: compactness, accessibility, freedom from vibration, flexibility, silence, and reasonable cost. Little need be said in regard to these as they are almost self-evident to any automobile engineer.

The reliability of an engine is the final proof of the skill of its designer in mastering every little detail. This is particularly true of an aeroplane engine because its service is so much more severe than that of an automobile engine that any weakness will show itself much sooner. Since weight is of such great importance, every member of an engine will probably be designed so as to be stressed to the maximum safe limit. For this reason any cast metal should be avoided as far as possible because of its uncertain strength. In nine engines a certain cast member will be amply strong, yet in the tenth some imperfection in the casting may cause a failure at a critical moment. Forged or rolled steel is one of the most dependable materials known to-day, and as it is also the lightest for a given strength, it is ideal for aeroplane engines. Since the greatest strength of steel is utilized when the stress acting on it is one of tension, it is advisable to design the engine so that parts which sustain the greatest strains shall meet with purely tensional stresses as far as possible.

Lubrication is another factor on which the reliability of an engine is dependent, and it is receiving more and more attention from designers. It is probably the one point on which the success or failure of a heavily worked engine hinges more than anything else. One of the improvements in lubricating systems which is gaining favor at present is that of cooling the oil after it has been used once, and before using it a second time. The reason for this is that oil apparently deteriorates upon prolonged exposure to heat, causing a falling off of the power of an engine because of inferior lubrication.

As a result of general observation many people consider that the more closely a design adheres to standard automobile types, the greater its reliability. This is probably because such designs have borrowed from the automobile many details which were learned from long and costly experience, but it does not mean that other types, such as radial or revolving, may not become just as reliable after sufficient development. There is no fundamental reason why the vertical or V-type engine should be more reliable than any other.

An aeroplane engine must, of course, be as economical as possible of both fuel and oil. Fuel economy implies a high compression, since efficiency rises with the compression ratio; and careful workmanship, so as to eliminate any unnecessary friction.

For any particular type of engine there are three places to look for a possibility of improved efficiency: The carbureter, gas passages, and ignition system. These are facts well known to automobile engineers and have been the cause of much research, the results of which would tend to make one look with suspicion upon the long unjacketed manifolds used on some aeroplane engines.

For very high engine speeds it has been proved that the number and location of the spark plugs has an appreciable effect upon efficiency. When two-point ignition is used, failure of one of the plugs must be guarded against because it will not cause missing and therefore may not be detected. Since two-point ignition requires a smaller angle of advance than the single-point, the failure of one plug will cause late ignition in its cylinder, with its resultant heating and lowered efficiency.

At present the magneto reigns supreme for the ignition of aeroplane engines, but it may be replaced soon by some of the well-known battery systems, because of the increasing necessity for an electric generator for wireless outfits, searchlights, stabilizers, etc.

It almost goes without saying that any unnecessary weight on an aeroplane engine must be eliminated, and that no part should be any heavier than it must be to safely resist deflection or rupture. Some designers are so anxious for a light engine that they unfortunately pare down too much on vital parts, including bearings.

There are, however, three other factors which determine weight: method of cooling, piston speed, and cylinder arrangement.

The same arguments of simplicity and light weight which are so well known to automobile engineers, are again revived in regard to air-cooled aeroplane engines. In spite of the fact that one American manufacturer has made an undisputed success of an air-cooled automobile engine, there seems to be but little tendency for others to follow his lead. The heavy duty required of the aeroplane engine, and the necessity for high power, increase the difficulties of air-cooling. For engines with revolving cylinders this form of cooling is almost essential because of the difficulty of making water connections. It limits, however, the size of the cylinders which can be cooled satisfactorily and large piston area can be secured only by a multiplicity of cylinders. Vertical and V-type engines must, of course, have a forced air draft, but this decreases the simplicity of this system.

The combination of air-cooling for the cylinders and water-cooling for the heads and valves, as used on the Wolseley 90 horse-power engine, is an interesting compromise which gives the reliable cooling of water, and yet saves much of the weight of the usual water-cooled system.

The power developed by any engine increases at the same rate as the piston speed, provided the valve area is increased also so that the m. e. p. will be unchanged. In other words, doubling the piston speed of an engine will double its power and hence cut the weight per horse-power in half. When speeds much higher than those used at present are attempted, many difficulties arise which are of such a serious nature that many engineers refuse to have anything to do with a high-speed engine. However, such a considerable weight reduction is possible by the use of high speeds that it is thoroughly worth while to investigate the factors which limit the satisfactory speed of an engine, and see what can be done to minimize their influences.

Undoubtedly the most prolific source of trouble when high speeds are attempted, is the valves and their mechanism. When one considers that with the possible exception of ignition, they are the most unreliable parts of an engine even at the speeds normally employed, and that their hammering action increases as the square of the speed, it can be appreciated that all possible means should be taken to reduce the forces involved as far as possible; this being particularly difficult with the high-speed engine because the size and hence the weight of a valve for a given cylinder diameter must be increased as the piston speed is raised in order that the volumetric efficiency be not sacrificed.

The first step to take in this direction is to eliminate the overhead valve which is operated by rocker arms and long push-rods from a camshaft located at some distance from the valves. In order to do this, either an L-head should be adopted, as in the case of the Sturtevant and Sunbeam, or an overhead camshaft as in the case of the Mercedes and Green. It is claimed that the latter construction gives a higher m. e. p. than the former and is less liable to cause trouble from warped cylinders because of uneven expansion, but it is certainly more complicated.

Whichever construction is adopted, the valve forces will be reduced materially by a high stroke-bore ratio. The time taken to open and close the valves will increase as the r. p. m. is decreased, and a long-stroke engine has, of course, a lower r. p. m. for a given piston speed than a short-stroke engine. The longer the period taken to open a valve, the less its acceleration, and hence the less the force required to operate it. It is possible to make a further reduction of valve forces by reducing the size of the valves and increasing their number so as to maintain the same port area. As an example, consider a single cylinder with one intake valve in one case, and a similar cylinder with four valves, each of half the diameter, in the second case. The total valve area in both cases will be identical, since area varies with the square of the diameter, but the weight of the single valve will be eight times the weight of the smaller valve, since weight varies with the cube of the diameter. Also, the large valve will have to lift twice as far as the smaller in order to get its maximum port area; hence the acceleration will be twice as great. Any force may be measured by the product of weight and acceleration; thus the forces involved with a single valve will be sixteen times as great as with any one of four valves each of half the diameter of the former. It is easy to understand why two intake and two exhaust valves are used for each cylinder of the Sturtevant "E-4" and Curtiss "V" engines.

* From a paper read before the Society of Automobile Engineers by Neil MacCoull, Jr., Associate Editor *Aerial Age Weekly*.

Increasing the number of cylinders has a similar effect on the valve action to that of increasing the number of valves per cylinder, because as the number of cylinders increases, the size of the cylinders and valves decreases if their total areas are to remain constant, as they must for equal power at equal piston speeds. With the smaller cylinders the smaller strokes (for equal stroke-bore ratio) will require a higher r. p. m. for the same piston speed, and thus the valve action will be more rapid. There will still be, however, a considerable reduction of the valve forces, as shown by the fact that doubling the number of cylinders decreases the forces on each valve about 65 per cent.

The best remedy of all for the unreliability of poppet valves at high speeds will be to dispense with them entirely by the use of some type of rotary or sleeve valve. The most serious objection to some of the better valves of these types as used on automobiles is their leakage, for it is difficult, if not impossible, to make them as tight as an ideal poppet valve. The question of leakage, is, however, important only when maximum torque is required at low speed. This is a condition never found on an aeroplane because the propeller torque varies as the square of the r. p. m. and consequently at low speeds there is almost no torque. At high speeds where the propeller torque is high, experiments have shown that a little valve leakage has practically no effect on the engine torque. Hence, aeroplane service is far more favorable to rotary and sleeve valves than automobile service. It should be observed, however, that many valves of these types require a heavier construction than the poppet valve.

Aside from valve trouble, the most serious limitations to the speed of an engine are the wear, and, with certain cylinder arrangements, the vibration caused by the reciprocating inertia forces; in other words, the forces necessary to start, stop and reverse the pistons and the reciprocating parts of the connecting-rods. These forces will lie between the values given by the two following equations:

$$F = \frac{K_5 PV}{f}(1 + a), \text{ and} \qquad (1)$$

$$F = \frac{K_6 V^{\frac{3}{2}} \sqrt{P}}{f}(1 + a). \qquad (2)$$

In which: V = piston speed in feet per minute.
P = horse-power per cylinder,
f = stroke-bore ratio,
K_5, K_6, = constants, and

$$a = \text{angularity of the connecting-rod} = \frac{\text{crank radius}}{\text{rod length}}$$

The first equation is based on the assumption that all similar dimensions of any equivalent parts of two engines which differ only in size, have a certain ratio to each other, e. g., if the diameter of the piston be doubled, then its length and thickness will be doubled also. Granting this assumption, the volumes of any two equivalent parts of similar engines will vary as the cube of any similar dimensions, such as the cylinder diameter. Since weight is proportional to volume, the above may be expressed by the equation:

$$W = K_1 d^3 \qquad (3)$$

The second equation will be true if the thickness of metal in any part is determined by foundry or machining requirements only, rather than by strength, and will be constant, not varying with the other dimensions. In this case, the volumes of any two equivalent parts of similar engines will be proportional to the areas of their surfaces, which vary as the square of any similar dimensions. This may be expressed thus:

$$W = K_2 d^2 \qquad (4)$$

As any part of an engine is made up of parts which may be classed under one or the other of these assumptions, its weight will lie between the values given by equations (1) and (2).

The most interesting fact revealed by these equations is that for a given power and piston speed the inertia forces in an engine may be reduced 50 per cent by doubling the stroke-bore ratio. Unfortunately a long-stroke engine is heavier than one with a short stroke, because of the larger crankcase and longer cylinders required. Just what is the best value of the ratio is one of the fine points of design which will probably not be settled for some time to come. Judging from automobile practice it will probably lie between 1.5 and 1.8.

As one would expect, the inertia forces increase with the piston speed, possibly a little faster in some designs, but this need not be very serious if the designer takes it into consideration and provides sufficient bearing area. Since these forces are directly proportional to the weight of the reciprocating parts, it is very important that they should be made as light as possible. It is not often that the connecting-rods are much heavier than necessary, but an appreciable saving may frequently be made in the weight of the piston by machining the inner surface. This is expensive but worth the price. Another considerable reduction in weight may be made by using a lighter metal than iron, such as aluminium hardened by traces of copper and tungsten. Such an alloy has been found to be an excellent bearing material and is stronger than cast iron, though it weighs less than half as much.

In the conventional four- and eight-cylinder engines the inertia forces are not completely balanced, and will consequently cause considerable vibration. In the former the total unbalanced force is usually about equal to the inertia force in one cylinder, and causes vertical vibration. The force causing vibration in the 90 degree "eight" is about 40 per cent greater than the inertia force of one cylinder, but since this latter is only about one half as great as that of the four-cylinder engine, the vibration of an "eight" will be about 70 per cent of that of a "four" of the corresponding power and piston speed.

The six-cylinder engine is theoretically perfectly balanced, as are also those engines with revolving cylinders. It is possible to perfectly counterbalance a radial engine of any number of cylinders except for an almost negligible force resulting when the connecting-rods are pinned to a master rod instead of bearing on the crank-pin. As in the automobile, vibration has a tendency to loosen bolts, wires and joints of all types, besides being intensely disagreeable; and should accordingly be kept within limits.

Another drawback to high engine speeds is that the propeller must be driven through gearing in order to develop its best efficiency. Much of the loss of efficiency resulting from driving through gears may be regained in the propeller, however, because the speed of most direct-driven propellers is higher than advisable for their best efficiency, and when gearing must be used, the propeller may just as well be run at a lower speed than is now general, with a resulting higher efficiency.

The weight of all parts of engines of small power will vary nearly as expressed by formula (4). Hence the total weight of all the cylinders of an engine will be entirely independent of the number of cylinders, because both the weight and power of any cylinder are functions of the square of the bore. This means that if the power of one cylinder be divided among two, each of the smaller cylinders will weigh but half as much as the first; hence the total weight will be unchanged. For large engines, in which the weight variation will follow formula (3) more closely than formula (4), it can be shown that there will be a decided saving in the total cylinder weight as the number of cylinders is increased.

The greatest saving in weight effected by the cylinder arrangement is in the crankcase and crankshaft. The longer these are the heavier they must be in proportion, because of the increasing necessity for rigidity when many bearings must be kept in line. Consequently, when all cylinders are in line, a six-cylinder engine will be heavier than a "four," and an "eight" and a "twelve" will be correspondingly heavier, to say nothing of their awkward length. The V-type cylinder arrangement saves about 50 per cent of the weight of the shaft and crankcase. In this arrangement the eight-cylinder engine is still lighter than the "V-twelve." The last step in the reduction of the weight of an engine by cylinder arrangement, is that type in which all cylinders are equally spaced about a single crank. This construction brings in, however, many difficulties unknown to the vertical and V engines, particularly that of oiling when the cylinders are radial in a vertical plane. All details are so completely different from those of any type of engine used in automobile practice that experience gained in this line will be of little value. The designer must plunge into a very new and comparatively undeveloped field, but the possibilities of this type are a great inducement to develop it.

Kinematographics*

Numerous attempts have been made of late to improve the cinematograph, especially in projection; and new applications are being found.

Some of the deficiencies of the moving picture are a lack of relief or stereoscopic effect in the pictures, and a lack of correspondence between the motion in the picture and the speech of the actors.

To correct the first weakness, apparatus has been devised, similar to an opera glass, by the use of which the spectator is supposed to get the stereoscopic effect.

In the case of double picture reproduction, in which a film broader than usual is required, the apparatus involves great complications. A departure from standard dimensions also obviously offers objections from the standpoint of adaptation to standard models and fittings.

Two methods of securing stereoscopic effects in cinematograms are employed. One utilizes the standard film, placing the two pictures one above the other and showing them alternately, in succession. The other presents them side by side, using a wider film. The first method gives results deficient in clearness. The second method requires a special form or adjustment of apparatus.

In color cinematography, likewise several methods may be distinguished. In one complementary colors are used, which at the rapid rate of succession give such approximate color effects as we obtain in color photography. For instance, several partial pictures may be taken in different color values and superposed in projection. For this, three objectives are required, and the film is comparatively expensive. Although the extension of the film is partly avoided by the subdivision of the picture field, it is not always possible with three objectives to utilize effectively the entire film surface.

Ruled screens have been applied, giving results from which monochromes are made after the process of tricolor photography. A two color process has also been used under the name of "Kinemacolor."

While a simple two-color process will not give all the colors in their natural values, the "Kinemacolor" process is capable of producing pictures resembling nature. The natural colors, corresponding to the two colors of the filters used, are well reproduced, while those less closely related are poorly represented. The usual form of "Kinemacolor" use blue-green and orange-red filter components, i. e., almost complementary colors, both of which appear nearer to the yellow side of the "color circle." Some attempt to correct this has been made by doubling the two-color processes and interposing compensatory color effects. But, in spite of suggestions repeatedly advanced, the hand-painted black-and-white positive film is the only really successful one adopted up to the present time.

Numerous attempts have been made to produce the synchronous perception of picture and sound—a field still open to experiment.

An obviously simple and practical plan is that of using the gramaphone with the cinematograph. To insure proper correspondence, special connecting devices have been constructed, which are particularly directed to the connection of new discs, as ordinary gramaphone discs are soon played off.

To obtain perfect synchronous reproduction, picture and sound must be taken synchronously. What has been done is as yet in the experimental stage.

The principle of the film has been applied to sound by creating sound images with more or less strong illumination by means of light sources influenced by telephone currents, or by the use of selenium cells (Ruhmer's photographone). The sound waves have thus been practically photographed, and the film used as a filter, to act in synchronous operation with the picture film and in a direction the reverse of the taking process, upon electric conductors (selenium cells, etc.) of a loud speaking telephone.

"Flickering," once so troublesome, has in modern apparatus been practically eliminated through optical compensation by the aid of prisms.

Again, danger from fire has been greatly reduced by substituting for the readily inflammable celluloid films other celluloid-like compositions equally transparent, such as cellulose acetate. Furthermore, automatic fire-extinguishers have been introduced. Some of these devices on being heated generate fire-extinguishing gases, such as carbonic acid, ammonia and water vapor, which act directly upon the passing film.

Many a new field will be developed for popular amusement and for scientific investigation. Already, we have special apparatus for Roentgen cinematography, and for deep sea investigation in which the water-tight apparatus is driven by built-in electromotors, and numerous moving phenomena have been studied, including bullets in motion.

*From *Umschau*.

Nicotine from Waste Tobacco Leaves

A description is given by MM. Chuard and Mellet (*Schweiz. Apoth. Zeit.*, 1914, Volume LII, page 424) of the method used in Switzerland for the manufacture of nicotine from the leaves rejected as unsuitable for the preparation of tobacco. The usual process is to extract the nicotine from these leaves immediately after the removal of the crop of choice leaves, but the experiments cited show that this is a mistake. If the stripped stems be left in the ground, and the soil treated with sodium nitrate, there will be a further growth of leaves, and consequently an increased yield of nicotine. For example in some cases the amount of the alkaloid obtained was increased by as much as seventy-seven per cent.

When the nicotine was extracted from the plants at once the average yield was 0.725 gramme per plant, whereas, when the leaves were allowed to grow again, the yield was increased to 1.284 gramme.

It was proved that the sodium nitrate was not directly responsible for the production of nicotine, but that it acted indirectly as a fertilizer, stimulating the growth of the plant. The proportion of nicotine showed considerable variations in different parts of the same plant, much more being present in the roots and shoots than in the stems.—*Knowledge.*

A Printing Telegraph

An American Conception That Is Revolutionizing the Transmission of Information

Printing telegraphs are probably of American origin, and one of the first apparatus which Morse brought to perfection was of this nature. In this, as in some other branches of telegraphy, however, Morse seems to have given only the first idea, and to have left it to the energy of others to convert it into a reality.

In 1854 David Hughes, an American, invented a successful printing telegraph which has been widely used in Europe, the essential principles of which were the synchronous movement of revolving wheels having the letters of the alphabet raised on their peripheries, and a paper tape just clear of the wheel. When a current was received, the tape was raised in momentary contact with the wheel, and the letter just opposite the paper at that time printed. The speed of this device is limited to about thirty words per minute, owing to the character of the line signal.

One of the most valuable contributions to the art of printing telegraphy was the so-called Baudot system, invented by M. Baudot, a Frenchman, in about the year 1870 and presented by him to the French government. Practically all the present successful systems are based upon the five-unit alphabet invented by him. The Baudot system has also had wide usage in Europe. The

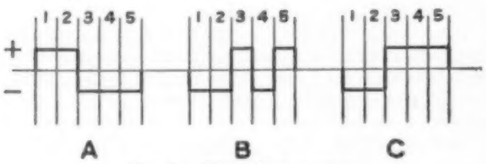


Fig. 1.—Signaling system.

system is a synchronous one. The selection is effected by commutators at each end of the line and by brushes revolving exactly in step with each other. There are five segments in the commutator which controls the letters, and the different letters are controlled by sending different permutations of positive and negative impulses from these segments. The transmitting apparatus is very simple, consisting of five keys similar to piano keys, but requires considerable training and skill to operate it. The operator must press different combinations of these keys for every letter, and must do it at a uniform rate of speed, once for every revolution of the brushes on the commutator. The receiving apparatus prints the message on a narrow tape, which is then pasted on a form for delivery.

The Morkrum system, which is now being quite extensively used in all classes of telegraph service, uses the Baudot alphabet, but provides keyboard transmission and a page printer for receiving. With this system it is not necessary for the operator to understand the Morse code or have any special training, as anyone who can operate a typewriter keyboard can do the work. This system also greatly increases the capacity of telegraph lines.

An operator working on a keyboard, similar to that of a standard typewriter, sends out over the line signals which actuate a typewriter at the distant end of the line. All the functions of the typewriter which are normally controlled by hand, such as turning up a new line or bringing the carriage back to start a new line, are controlled from the keyboard at the sending end of the line, and all this is done over a single wire, which is also operated duplex; that is, the transmission of

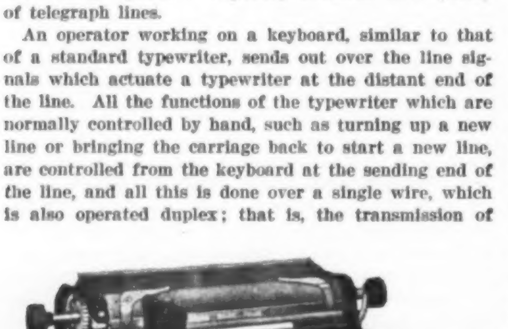


Fig. 2.—Keybord and home recorder.

messages in both directions over the wire can be accomplished simultaneously.

Two methods of transmitting are used in the Morkrum system; first, the direct-acting keyboard system, in which the operation of the keyboard at the sending end actuates the printing mechanisms at the receiving end directly, without any intermediate operations; and, second, tape transmission, in which the messages are first prepared on a perforated tape by means of a keyboard perforator. This tape is then used to automatically transmit the signals over the line at a high rate of speed. The printing mechanism at the receiving end is identical in either case, whether the transmission is accomplished by means of direct keyboard operation or by the use of the perforated tape and automatic transmission.

The selective system is based on the five-unit Baudot alphabet. That part of the line signal which controls the printing of letters, or the operation of the other functions of the typewriter, is divided into five time intervals, and the selective signaling is accomplished by combinations of reversals of polarity of the current sent to the line during these five time intervals. This allows thirty-two selections to be made over the line, and by using a shift of the typewheel, fifty-three letters, figures and characters can be printed.

Fig. 1 illustrates this method of signaling. In the letter *A* positive current is sent to the line for the first two time intervals and negative current for the last three time intervals. These signaling currents operate the polar relay at the receiving end and the currents of negative polarity are used to control the selective mechanism.

As in this system there is never to exceed three, and an average of only two signaling currents sent to the line for each letter, the frequency of the line signal is very low. This is important, as the higher the frequency of the signals and, consequently, the shorter the duration of the signaling currents, the greater becomes the difficulty of actuating the selective mechanism in a positive manner. The low frequency has given great reliability, particularly in bad weather; and there have been numerous instances where the Morkrum has been able to work through severe storms that have made the working of wires extremely difficult. This feature, combined with the reliable synchronizing system, has made the Morkrum valuable for long line printer work heretofore considered impracticable. There are a number of long circuits in duplex operation, with from two to five repeaters.

Fig. 2 shows a printer unit mounted on a keyboard for direct transmission. When a letter on the keyboard is depressed it sets up five pole-changers in the combination which corresponds to that key. The transmission of the signal thus set up is accomplished by a brush revolving on a commutator. When the key is fully depressed a clutch is released which allows the brush to make one revolution and transmit the signal to the line.

The keyboard action is very light, requiring only a slight touch to start it, the stroke being completed by an electromagnet, and it can be operated all day with much less fatigue than an ordinary typewriter. It also has a key lock which holds the key down until the complete signal has been sent, and also prevents any other key from being depressed until the signal for the preceding letter has been completed.

In the keyboard system the selection at the receiving end is accomplished by means of a bank of relays, which successively connect five lock relays, which control the printing mechanism, to the contact point of the main line relay. Before sending out the selective signal the motor transmitter sends out a starting pulse, which starts the action of the receiver bank.

The direct keyboard system is not synchronous in the ordinary sense of the word, but is roughly isochronous; that is, the receiving mechanism is adjusted to run at approximately the same speed as the transmitting mechanism, and a governing rheostat is provided to regulate the speed of the receiving mechanism. With this arrangement, any difference in the transmitting and receiving speed is not cumulative, as the receiving mechanism and the transmitting mechanism start together at the beginning of each letter. The receiving mechanism is arranged so that it connects the selective locks to the line relay for only a short portion of the duration of each time interval of the transmitted signal; in other words, only the peak of the wave is used by the receiving mechanism, and this fact allows of considerable distortion of the wave form without affecting the action of the selecting mechanism.

For tape transmission, the various combinations are formed by a series of holes punched crosswise on the tape.

Fig. 3 shows the Morkrum keyboard perforator, which has a keyboard similar to that of a standard typewriter. There are six rows of holes on the tape. The continuous row of small holes is used to feed the tape in the transmitter. Different combinations of holes in the five remaining rows, which are placed two in front of and three behind the feed row, represent the different signals to be transmitted and control the polarity of the five selective impulses which are sent over the line for every signal. In the tape system, as in the keyboard system, the selective mechanism is controlled by different combinations of polarity of five time intervals.

Fig. 3.—The keyboard perforator.

The five pole-changers used in transmission, instead of being controlled directly by the keyboard, are controlled by the arrangement of the holes in the perforated tape. At the transmitting end a brush revolving on a commutator transmits the signals set up by the tape to the line, but instead of being controlled by a clutch, as in the keyboard system, this brush revolves continuously. At the receiving end there is a similar commutator to which the five selective locks are connected, and there is also a continuously revolving brush.

It is apparent that the brushes of the transmitter and the receiver must be over corresponding segments at the same instant. To accomplish this, means are provided for keeping them in unison. The brush at the receiving end is run at a speed which is slightly faster than that of the brush at the transmitting end. The transmitter brush sends out a correcting pulse every revolution and this operates a correcting mechanism at the receiving end which will retard the receiver brush sufficiently to keep the two ends in unison.

The typewriter used in connection with the system was specially designed for the purpose. A revolving typewheel is used, and the five selective impulses control a mechanical selecting device which regulates the rotation of the typewheel and stops it opposite the proper letter.

The platen of the typewriter is stationary, and the printing mechanism moves, which is the reverse of typewriter practice. The printer accommodates all standard telegraph blanks, and the stationary platen is of considerable advantage in feeding blanks, also when it is desired to use a large roll of paper in the printer.

With the direct keyboard system it is customary to use a home recording printer with a roll of paper. In tape transmission the tape is the home record and no home printer is required.

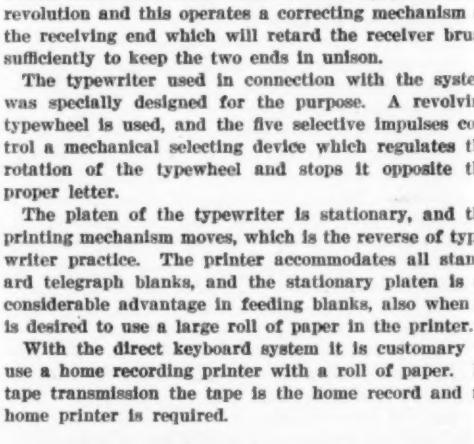


Fig. 4.—Distributor and transmitter.

The direct keyboard and tape transmission systems each have their special uses, depending upon the length of the line and on the character and volume of business to be handled.

The direct keyboard system operated duplex has a capacity of about eleven hundred commercial messages in a nine-hour day. The tape operated system has a capacity of about two thousand commercial messages in a nine-hour day.

Printers on this system were first introduced in regular service by the Postal Telegraph-Cable Company between New York and Boston. That circuit has been in regular operation for several years, and a number of other circuits have been installed by that company.

The Western Union Telegraph Company is using the Morkrum tape system quite extensively on its main lines all over the country, the longest circuits being those in operation between Chicago and San Francisco and Chicago and Los Angeles, about twenty-three hundred miles, with four repeaters each.

This system is extensively used in Canada by both the Canadian Pacific Railway and the Great Northwestern Telegraph Company. A number of principal railroads in the United States is using the Morkrum system.

One of the most interesting developments of the Morkrum printing telegraph has been in the distribution of news from the headquarters of the Associated Press to the various newspaper offices in New York city. In this work the press matter written on the keyboard at the Associated Press office is received simultaneously by as many as twelve receiving stations located at the various newspaper offices.

X-Ray Examination of "Built-Up" Mica*

By C. N. Moore

[Until very recently the thought of an X-ray tube immediately called to mind its application to medicine and surgery. The Coolidge tube, however, has broadened the useful scope of the application of X-rays so successfully, that it is now employed widely for engineering purposes.—Editor.]

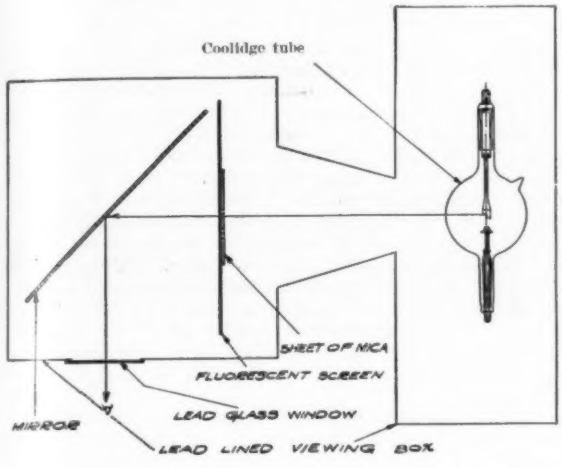


Fig. 1. Diagram of viewing box and fluorescent screen.

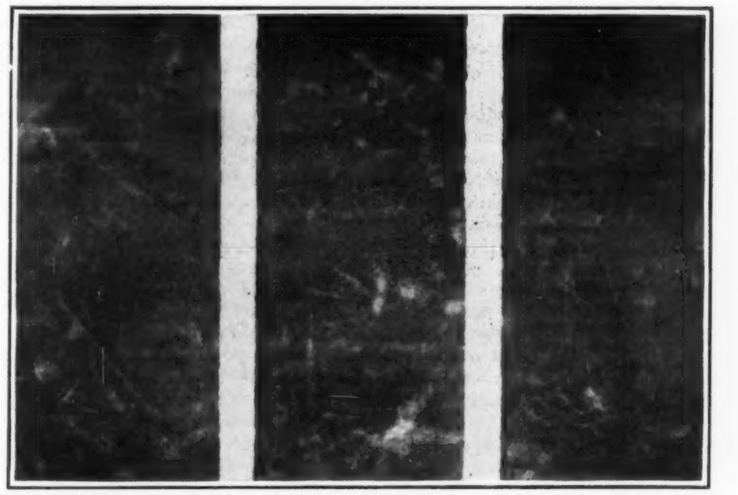


Fig. 4. Radiograph of mica showing presence of particles of foreign material.

The process of manufacturing "built-up" mica for use as an insulating material in electrical machinery consists essentially in pasting together, at an elevated temperature under pressure, thin flakes of mica with a suitable binder, planing down the resulting product to the required thickness, and cutting it into sheets of the required size. In this process, certain defects which would affect the insulating qualities of the finished product have to be guarded against. Among these are the presence of foreign materials of a metallic nature, and of areas not of the required thickness In practice, these defects are detected by subjecting the material to very careful visual inspection and gauging with a micrometer. This, however, entails considerable labor. The successful application of X-rays to the detecting of defects in such materials as steel and copper castings, already described in earlier issues of this publication, suggested the possibility of utilizing X-rays as a means of increasing the efficiency of the regular inspection of mica.

With this end in view, Dr. Davey and the writer obtained micas (some known to be good and others known to be defective) for examination in the Research Laboratory. These samples were about 0.032 of an inch in thickness and had been cut into small sheets of the required size for placing in the commutators. These pieces were placed upon a fluorescent screen in a specially designed viewing box (Fig. 1) at a distance of 20 inches from a Coolidge X-ray tube. When the tube was operating with a current of about 6 milli-amperes and a parallel spark gap of 6 inches, the structure of the mica, as shown on the fluorescent screen, could be viewed from the outside of the box by means of a mirror set at an angle of 45 degrees to the screen.

*The General Electric Review.

Some of the samples examined contained small particles of iron oxide not visible to the eye on the surface of the sheet of mica. As iron oxide is much more opaque than mica to X-rays, this material showed up as black spots in the image of the mica on the fluorescent screen. Other samples examined contained small sections not as thick as the main portion of the sheet. These sections, being more transparent to X-rays, showed up as light spots in the image on the screen. Samples of uniform thickness which contained no foreign material gave images of uniform density upon the screen. It was found that the examination could be made very accurately and rapidly, one glance at the image on the screen being sufficient to detect the presence of any defects.

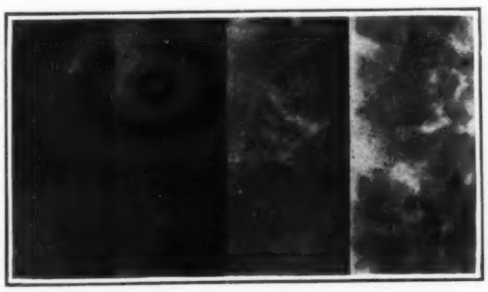


Fig. 3. Radiograph of sections of built-up mica showing a difference of thickness of 0.005 in.

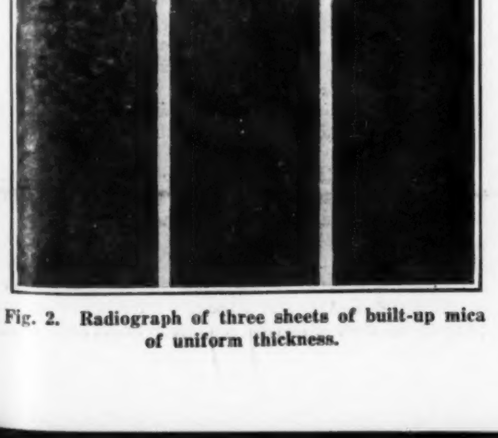


Fig. 2. Radiograph of three sheets of built-up mica of uniform thickness.

The nature of the images on the fluorescent screen is shown in the radiographs. These were taken on Seed X-ray plates, with an exposure of five minutes at a distance of 30 inches from a Coolidge tube. The tube was operated from an induction coil on 10 milliamperes with a parallel spark gap of 4 inches. Fig. 2 shows the radiograph of three sheets of fairly uniform thickness. The various flakes of mica which go together to make up the finished sheet are plainly visible. As these flakes are in most cases only a few thousandths of an inch in thickness, this radiograph shows what small differences of thickness may be detected by means of the X-rays and the flourescent screen. Fig. 3 illustrates this more clearly. In this case a sheet of mica 0.050 of an inch thick was planed down so that successive sections were 0.045, 0.035 and 0.020 inch thick. The radiograph of this sheet shows that a difference in thickness of 0.005 of an inch may readily be detected.

The ease with which foreign material may be detected as shown by Fig. 4. The particles of iron oxide present in this particular case were not visible on the surface, but they are plainly visible as black spots in the radiograph taken of the sheets of mica.

Fig. 5 shows a radiograph of four sheets of mica 0.032 of an inch thick with small areas considerably thinner than the main portion of the sheet. These thinner areas show up as light spots in the radiograph.

The results obtained on an experimental scale in the laboratory have demonstrated the adaptability of the X-ray apparatus as a factory tool for the inspection not only of "built-up" mica but of any similar material of not too great a thickness.

Crude Nitrogen in Natural Gases

The crude nitrogen fractions separated from natural gases, such as fire-damp and the gases emitted by thermal springs, have been examined by MM. Moureu and Lepape (*Comptes Rendus*, 1914, Volume CLVIII, page 839). The analyses show that the crude nitrogen is remarkably constant in its composition, whatever its origin, and is composed of very similar proportions of nitrogen, argon, xenon, krypton, and helium. From this fact the conclusion is drawn that these constituents have a common origin, possibly, in the nebulous period. Variations in their quantities may be attributed to diffusion or other physical processes.—*Knowledge.*

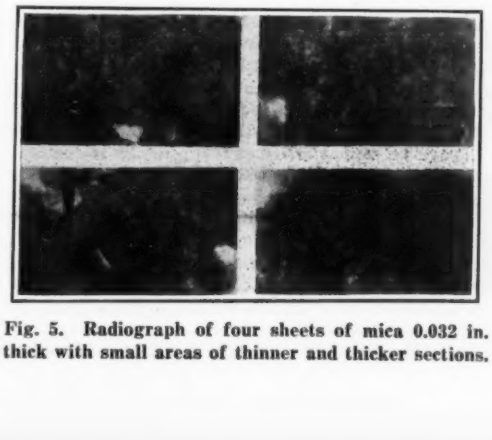


Fig. 5. Radiograph of four sheets of mica 0.032 in. thick with small areas of thinner and thicker sections.

Atoms, Molecules and Electrons

A Popular Exposition of an Abstruse Scientific Theory

By Norris W. Rakestraw

CAN you imagine the commotion which would be caused if a swarm of angry bumble-bees were to be set free inside a copper wash-boiler? What a wild jumble of collisions among themselves and with the copper walls! Though the analogy is not complete, this apparently aimless confusion is what is taking place about us all the time—in the air, or in any gas which is confined within definite limits.

And, did you ever stop to notice how wonderful it is that a bar of steel can hold a weight of thousands of pounds, although it is itself nothing but a cluster of rapidly-moving little particles which are not even touching each other, but are only held together by some sort of invisible forces?

And, did you ever wonder at the simple fact that when you drop sugar into water it soon actually disappears—dissolves you say?

These, and many other things, are the wonders which the scientist attributes to certain little bodies which are so small that millions of them must be grouped together before they can be seen through the most powerful microscopes. These little particles are called molecules, and, although they are so small that there are 400,000-000,000,000,000,000 of them in every cubic inch of gas, still, their combined force, as they fly about in the air, beating continually upon everything, amounts to fifteen pounds upon every square inch of surface. In fact, these little bodies are of the greatest importance to us, because every physical object is entirely made up of them.

Astonishing as this may seem, our wonder increases as we learn that these particles are themselves composed of a number of smaller ones called atoms, and it is now believed that these, too, are in turn aggregates of yet smaller bodies called electrons or corpuscles.

Notwithstanding the fact that popular scientific literature is filled with references to *molecules*, *atoms*, *electrons*, and *ions*, there is considerable misunderstanding among non-technical readers concerning the real nature of these things and the difference between them. Although the theoretical and mathematical consideration of molecules and atoms is rather abstruse and involved, the general facts about them are quite understandable to anyone, after a few definitions and suggestions.

Before going further, there is one notion of which it is necessary to rid oneself: namely, the idea that there is very much direct knowledge of these particles to be had at the present time. Although scientists speak very positively about them, no one has ever directly observed the actions of molecules. Whether or not they have a real objective existence, we have no direct means of knowing; the most we can say is, that matter behaves *as if they did exist*. If, however, by assuming their existence and certain facts about them we can arrive at theoretical conclusions which are capable of experimental confirmation, we are justified in considering our assumptions to be true. In this way, many things have been learned which lead us to put considerable faith in the actual existence of molecules; we can compute their number, size, weight, and velocity, though we cannot tell much about their appearance, their internal structure, nor the forces which govern their every action.

In order to understand the molecular theory, we must first know a few things about the nature of chemical substances. Substances in general are divided into two classes: elements and compounds. Most forms of matter can be decomposed by chemical means into two or more others of simpler composition. Forms which can be thus decomposed are called compounds. But, sooner or later, certain forms are arrived at, which cannot, by any amount of effort, be decomposed into simpler substances. These are called elements and may be considered the chemical units of which all the complex forms of matter are built up. There are about eighty of these elements known.

Now it would appear that any compound might be divided mechanically into an infinite number of parts. Mathematically, we might take a rock, for example, and smash it into as many pieces as we like, and no matter how small a piece we come to it can still be divided again. Chemically, however, there is a limit to this process. Although we cannot arrive at this point by mechanical means, there is considered to be an ultimate particle which, if we break it up, ceases to exist as a particle of rock and yields particles of simpler and entirely different substances. This smallest portion of a compound which can exist independently as such is called a molecule. We may define a molecule, then, as the smallest particle into which a compound substance can be divided without changing its chemical composition.

From the above, we see that a molecule is not an invisible body, and, indeed, we find, upon further division, that it is composed of smaller particles which are called atoms; these, however, are no longer particles of the compound but of the elements which compose it. Thus, a molecule of water is composed of two atoms of a gas, hydrogen, and one of another gas, oxygen. These atoms within the molecule cannot be further divided by chemical means. So we may define an atom as the smallest particle into which a chemical element can be divided.

We should notice, however, that although elements can be divided fundamentally into atoms, these atoms—when the element is not combined with any other element—group together to form molecules of the element, which are thus an intermediate step in the element's constitution. In most gaseous elements—oxygen, hydrogen, chlorine, for example—all the atoms are grouped in pairs, so that two atoms make up one molecule of the gas.

The atom of an element undergoes no change during ordinary chemical reactions and until quite recently was thought to be an indivisible unit. But now, from investigations in the field of radio-activity, the atom itself is believed to be composed of yet smaller particles called electrons, which appear to revolve about a common center within the atom. These electrons are found, on the basis of certain experiments and mathematical processes, to be only one seventeen-hundredth as large as the smallest atom, and their particular characteristic is that they are charged with negative electricity. The electrons of all atoms seem to be exactly alike, and there is reason to believe that they are the units of which all matter is composed.

Being so small, it might be supposed that we could have no evidence of the action of these three kinds of bodies—molecules, atoms, and electrons. On the contrary, however, there are many everyday phenomena for which they are directly responsible. Especially, is this true of molecules; and now, let us consider the part which they play in natural phenomena.

For our present purpose matter is conveniently divided into solids, liquids, and gases. These are called the three "states of aggregation," a term, which in itself, suggests that there is a different molecular structure in each case. Of the three, gases have the simplest molecular structure, and, indeed, it is found experimentally that all gases have a great many common physical properties; they have an equal number of molecules in equal volumes, they expand equally with increasing temperature, and contract equally with increasing pressure.

The molecular theory assumes that the molecules of which a gas is composed are moving rapidly in straight lines, collisions constantly taking place, one molecule with another, or with a wall of the containing vessel. As an example, let us take the case of a volume of hydrogen. Each hydrogen molecule is supposedly similar to every other hydrogen molecule and has an average velocity of 5,570 feet, or something over a mile per second. In that time, however, it makes about ten billion collisions with other molecules, for there are millions upon millions of them flying about in every cubic inch of the gas. As this motion is apparently constant, the molecules must be perfectly elastic; that is, none of their momentum is lost by impact with each other. What we call the pressure of the gas is nothing more nor less than the ceaseless bombardment of the walls of the vessel by the rapidly-moving molecules. Though each molecule is so small that its separate impact would be imperceptible, the combined force of the millions upon millions which are striking every square inch of surface of the walls goes to make up the total pressure of gas, which is thus proportional to the number of impacts in a given time and to the momentum of each molecule as it strikes. If the volume is increased, the distance is increased through which each molecule must pass; therefore, the number of impacts, and consequently the total pressure, is decreased. Temperature is a measure of the velocity of the molecules, and so increasing the temperature increases the number of impacts and the force of each impact—in other words, increases either the pressure or the volume.

Gases expand indefinitely; that is, no matter how much the containing vessel is enlarged the gas will always fill it completely. This is not, as is often supposed, because the molecules repel each other, but because they are rapidly moving in every direction and thus tend to scatter about in all directions till stopped by the containing walls. It can readily be shown that the gas molecules could not repel each other; on the contrary, they exert attractive forces. But, since ordinarily the space between molecules is thousands of times greater than the size of the molecules themselves, these attractive forces apparently have practically no effect.

We have seen that in gases the molecules move in straight lines, their attractive forces are so small as to be of no importance, and their size is negligible in proportion to the total volume. Now let us see what is the molecular structure of liquids.

Here, conditions are very different. The molecules seem to be less free to move about than in gases; they no longer move in short straight lines but thread their way among each other in curves, because of the action of their attractive forces. A sort of equilibrium is established between their energy of motion—their kinetic energy it is called—and the force of mutual attraction. In liquids, as well as in gases, the molecules are free to move about and fill every crack and corner of the containing vessel; but the characteristic property of a liquid is the fact that it has one free and distinct surface.

While a molecule is in the interior of the liquid the attraction of other molecules upon it is equal in all directions and these attractions thus neutralize each other. But, when the molecule comes close to the surface there is a greater pull inward than outward and it is drawn back again. Now, if we would write the mathematical equations or those forces acting, we would find that the position of equilibrium is reached when the liquid takes the form of a perfect sphere, and this is what always happens when the liquid is free to take its own shape—as when dropping through a vacuum. This force, at the surface pulling the molecules inward, produces a tangential force which is known as surface tension, and in many ways it acts exactly as though there were a rubber membrane stretched over the liquids. The important thing to note, here, however, is that the molecules are responsible for this.

Sometimes a molecule rushes to the surface with such a velocity that it overcomes the attractive forces and flies out of the liquid completely. It is then in exactly the same condition as a gas molecule and moves about in the air just as any other molecule of the air. As this continues, the liquid is said to *evaporate*, and, inasmuch as it is always the most swiftly moving molecules which can fly out of the liquid in this way, the slower ones are left behind and the liquid becomes cooler—as its temperature is only a measure of the velocity of its molecules.

In the case of solids, it is not yet very well known how the molecules arrange themselves. It seems that here they no longer move about freely, but are restricted in their motions to certain small areas. It is as though there were centers about which a number of molecules revolve in more or less regular orbits, and it is only with difficulty that they can escape from these restrictive forces.

The molecules resist all forces which tend to push them out of their normal areas of motion, and they tend always to return to these positions when the shape of the solid is deformed. This resisting force of the molecules is called elasticity, and it varies according to the nature of the substance.

We know that the restriction of the molecules to certain areas is not absolute, however, from the fact that molecules now and then escape from their restrictions and either move about in the solid, where they are shortly captured by other areas of restriction, or else, under exceptional circumstances, escape into the surrounding air. When the latter occurs, we have the phenomenon of *sublimation*, or the evaporation of a solid without passing through the liquid state. Ice, for example, kept below its melting point, will evaporate into the surrounding air without passing first into water. This process generally takes place to a much less extent in solids than in liquids, which shows that the molecules of a solid are held together much more firmly.

The tendency of typical solids to solidify from the liquid state in definite geometrical forms, or to form crystals as we say, is another indication of the action of inter-molecular forces. As yet, however, not much is known as to the molecular significance of crystalline forces. The most we can say is that in crystals (and a substance which is not crystalline is not a typical solid, though it may be hard and rigid) the molecular forces act along definite lines which we call crystalline axes.

The change which a solid undergoes upon dissolving in a liquid is an interesting one, and, here again, there is disagreement among scientists as to what actually takes place. When a soluble substance is placed in a liquid, the molecules of the liquid exert a certain attraction upon the molecules at the surface of the solid, and many of the latter, because this attractive force is now added to their own force of motion, are able to break away from

the restrictions of the solid, and are thus enabled to move about within the liquid exactly like liquid molecules. As this process of escape of the solid molecules goes on, there soon comes a time when a few of them, in wandering about in the liquid, again come in contact with the solid and are recaptured by the restrictive forces. And the more molecules that escape from the solid, the more there will be wandering about in the liquid, and the more there will be which will come in contact with the solid and be recaptured. This process will continue until there are just as many returning to the solid as there are escaping from it, and then we say that the solution is *saturated*, which does not mean that there is no more solid dissolving, but that there is just as much solidifying as there is dissolving. The solubility of a solid is thus determined by the mutual relation of three forces: the attractive force between the solid molecules; the attraction of the molecules of the liquid for those of the solid; and the force of motion of the solid molecules themselves. As heat increases, the latter force solids are generally more soluble in hot liquids than in cold.

When a very finely divided solid stands for a long time in a liquid in which it is only slightly soluble—as, for example, barium sulphate in water—the solid collects into larger and larger crystals. This is because the small crystals are more soluble than the larger ones and the molecules which escape from the smaller are deposited upon the larger, from which they cannot escape so easily, and thus the larger ones grow at the expense of the smaller ones.

Let us now turn to the consideration of those smaller particles which are called atoms. We have seen that molecules are complex bodies composed of a number of atoms. In most physical changes, the molecules act as units, but when we come to consider chemical changes, we find that the molecule is generally broken up and that the atoms are the units with which we must deal. The number of atoms in a molecule varies from two, in the case of simple compounds, to a hundred or more in the case of complicated organic substances. In some cases, there appears to be no distinction between the atom and the molecule, that is to say, the molecule seems to consist of but one atom.

Chemists have a convenient way of denoting substances by so-called formulas, which express the number and kind of atoms in the molecule of the substance. Thus, the formula for water, H_2O, indicates that there are two atoms of hydrogen (H) and one of oxygen (O) in the water molecule. The formula for sugar, $C_{12}H_{22}O_{11}$, shows that it is a more complicated substance, with twelve atoms of carbon, twenty-two of hydrogen and eleven of oxygen in the molecule.

In chemical changes, the atoms may be imagined to break away from their previous molecular groups and to unite in a new manner. The fact, which was noted in the early nineteenth century, that when substances combine chemically they always do so in definite proportions by weight, is what led to the formulation of the atomic theory, and is only explained upon the supposition that chemical reactions are reactions between small, independent particles of the substance which have equal masses.

What happens, for example, when silver nitrate, $AgNO_3$, is treated with common sodium chloride, NaCl, is that the chlorine from the latter and the NO_3, called the nitrate group, from the former, change places, and silver chloride, AgCl, and sodium nitrate, $NaNO_3$, are the result. Oftentimes merely heating a substance will cause its molecules to break up, as when limestone, $CaCO_3$ is heated to form lime, CaO, and carbon dioxide, CO_2.

A molecule is a little cluster or group of atoms which is held together by some sort of electrical force. When something happens to disturb the equilibrium of the group, some of the atoms may break away and others will, perhaps, take their places, or some other process of readjustment will take place. In such compounds as nitroglycerine, the equilibrium of the groups of atoms which form the molecules is very unstable, and a slight disturbance causes them to break up so violently that an explosion occurs.

The forces which hold the atoms together within the molecule are only imperfectly understood. They are probably of an electrical nature, as that theory best explains what is called the *valence* or "combining power" of the atoms. Some atoms, for example, will combine with one atom of hydrogen, others with two, others with three, and so on. The valence of these atoms is thus respectively one, two, and three. These "intermolecular" forces are often very great, and the breaking up of the molecule and the readjustment of its atoms is often accompanied by the liberation of considerable energy, generally in the form of heat, as in the burning of coal.

Chemical reactions generally take place much more rapidly when the substances are dissolved in water or some other liquid, for, then the molecules can move about and come in contact with each other much more readily, thus offering greatly increased opportunities for their respective atoms to unite or change places.

Reactions in solution are accompanied by another phenomenon of interest—one which is receiving much attention to-day. This is the process of *ionization*, or *dissociation* of dissolved substances. When certain substances are dissolved in certain liquids (water principally), some of the molecules of the former are broken up by the process of solution into parts called *ions*. These ions may be either single atoms or small groups of atoms. When sodium chloride, NaCl, is dissolved in water, the ions produced are single atoms, Na and Cl; but in the case of sulphuric acid, H_2SO_4, three ions are formed, two H and one SO_4.

What distinguishes a simple ion from an atom is the fact that the former carries a charge of electricity while the latter does not. When this charge is given up the ion is simply a free atom. These electric charges upon the ions are made use of in many ways in electro-chemistry. Indeed, the part which ions play in the field of chemistry is a very important one, but there is no space here to go into the matter more fully. The point to note is that under certain conditions molecules break up into fragments—atoms or groups of atoms—which carry electrical charges, either positive or negative, and that these charges exactly neutralize each other when the fragments, or ions, are united in the molecule.

Inasmuch as atoms and molecules are definite particles of matter, questions naturally arise as to their weight, size, etc. It would seem at first thought impossible to ascertain the weight of a particle which cannot even be seen, but there are several methods of doing so, most of which are rather complicated and involved. One method is enough to describe here, which is interesting as it consists in actually counting the atoms in a given volume of gas.

This method makes use of a substance called radium, which is constantly throwing off from itself what are called alpha-rays, which are now known to consist of atoms of a gas, helium. When these rays strike upon certain substances—as diamond, for example—they can be seen as a myriad of little sparks, each of which represents an individual helium atom. A little radium is placed in one end of a closed tube at the other end of which is a small hole of known area. A diamond is placed close to the small hole, and as some of the helium atoms will fly out through the hole, the number of flashes in a given time can be counted. It is a simple mathematical problem to determine what proportion of the total number of helium atoms will pass through the hole of known size, and as the volume of helium given off by radium in a given time has been carefully measured, the number of atoms in a given volume is readily determined, as well as the weight of each atom. The result from this method shows that the helium atom weighs about .000,000,000,000,000,000,000,0065 gram.

The scientist is not usually concerned with the actual weights of atoms and molecules, but is frequently very much interested in their *relative* weights. The "atomic weight" of an element is the relative weight of its atom compared to some standard, generally the atom of hydrogen or oxygen. As there are many properties of substances which depend upon the weight or number of molecules, the "molecular weight" can be determined by several methods. The atomic weight of an element is calculated from the molecular weight of its simplest compounds by an analytical determination of the percentage of the element in the compounds.

We have seen that molecules are composed of a number of atoms, and now, upon closer consideration of the atom, we find that it, too, consists of yet smaller particles which have been called *corpuscles* or *electrons*. A detailed development of the electron theory is much too complicated and mathematical to be attempted here, and those who may wish to follow it in detail are referred to the masterly works of J. J. Thomson who has been largely responsible for this theory. The results of the theory may here be outlined, however, along with its application to some familiar phenomena. And now we must turn from the chemical fields, with which we have been dealing, to the consideration of the behavior of electricity.

Perhaps no question has baffled the minds of scientists more completely and for a longer time than has that of the nature of electricity. The earliest idea was that it was a kind of subtle fluid—"electric fire" was the term Benjamin Franklin used. This conception was soon considered crude and imperfect, and many attempts were made to explain electricity as a form of energy, or a condition of matter of some sort. After many years of conflicting opinion, scientists have reverted to the earlier idea and have reached the conclusion that electricity *is* some sort of fluid—a gas if you choose to call it so—composed of exceedingly small particles called electrons.

Many experiments have been devised to show the actual existence of these particles. When an electric current is allowed to discharge through a partial vacuum rays, called "cathode rays," pass from the negative pole to the positive, causing that part of the tube to glow brilliantly. These rays can be deflected by a magnet or by an electric field and are found to carry negative electricity. They behave in all ways as though they were negatively charged particles of matter, and, indeed, they are known to be electrons in rapid motion, the velocity varying from 10,000 to 90,000 miles per second, this velocity being ascertained mathematically from the amount of their deflection by a known magnetic force.

By a rather complicated process of experiment and calculation, the mass of each of these particles has been determined, as well as the electric charge which each carries. It is found that the mass of an electron is only one seventeen-hundredth of that of a hydrogen atom, which has hitherto been the smallest particle with which we have dealt. Although the electric charge which is found to exist upon an electron seems exceedingly small, it is still so large compared to the size of the electron that if two electrons were placed one centimeter apart in a vacuum they would repel each other with a force more than a trillion trillion times greater than gravitational attraction. Indeed, the forces with which we are here dealing are so great that if we consider the electric current to be a gas, it exerts a pressure thousands of times greater than that of the atmosphere.

But, we have so far considered only negative electricity. What about positive charges? In our vacuum tube, which produced the "cathode rays," we shall find that there are also rays traveling in the opposite direction which carry a positive charge; but their velocity is very much less than that of the negative rays, and, measured by the same methods as the latter, the mass of the particles is found to be at least 1,700 times smaller. In fact, these positively charged particles appear to be nothing but positively charged atoms. Each of these atoms has lost a negative electron, thereby being changed from the neutral state into that of a *positively* charged atom.

All efforts to isolate positive electricity in the same manner that negative electricity has been isolated have failed. Positive electricity is always found to be matter from which the negatively charged electrons have been *substracted*. Each atom of matter is normally in the neutral state; but under certain conditions it may be *ionized*, that is, an electron may escape from it, leaving the remainder of the atom positively charged. Positive electricity, if it exists, appears to be inseparable from the atom. Thus, on the basis of the electron theory, an atom is a nucleus of positive electricity holding together a number of negatively charged corpuscles (or electrons), the negative electricity of the corpuscles exactly balancing the positive electricity of the nucleus.

The actions of these negatively charged electrons produce all the phenomena of electricity: their action upon each other when at rest produces static electricity; their motion through metals, liquids, or gases, is what we call the electric current. Materials in which some of the electrons can break away from the attraction within the atoms are good conductors; those in which the electrons are firmly held are insulators.

Electrons are capable of attaining enormous velocities, with the speed of light as a limiting maximum; and, it is astonishing to note that the mass of the electron varies with its velocity. This variation in mass is due to what we may call the electron's friction with the ether—that intangible, all-pervading medium which transmits light. Upon further investigation of this fact, it is found that *all* of the mass of the electron is due to its velocity, that the electron is nothing but a moving charge of electricity, carrying with it a small part of the ether, much as a boat, when in motion, carries some of the water along with it. The amount of ether thus carried along by friction is obviously proportional to the velocity of the electron.

Light, heat, the electro-magnetic waves used in wireless telegraphy, and all other forms of etheric vibration are explained as being caused by changes in the motion of electrons. When electrons in rapid motion are brought to a stop their energy of motion is converted into radiant energy of one kind or another. X-rays are of this nature, and are produced when the "cathode rays" strike the glass walls of the tube.

X-rays are most familiar because of their remarkable penetrating power. Not many years ago, the world was astounded by the discovery of substances which spontaneously give off rays of equally great penetrating power. Several of these so-called "radio-active" elements are known, the principal one being radium. This element, wherever it is found, is continually giving off three kinds of rays, known respectively as the alpha, beta, and gamma rays. The former are the least penetrating, are only slightly deflected by a magnet, and have been found to consist of atoms of the gas helium. The beta rays are negatively charged, are easily deflected by a magnet, and are found to consist of electrons thrown off with a great velocity. The gamma rays are the most penetrating of all and do not seem to consist of material particles. They are identical with the X-rays, which it will be remembered are vibrations in the ether caused by the electrons.

Experiments upon the behavior of radium have revolutionized many scientific theories. The rays which it gives off arise from the "explosion" of the atoms of the element—a process which is going on continually. The atoms are breaking up, and in the process particles are thrown off with great velocity. These particles are electrons and helium atoms, and originally formed part of the radium atom.

Here is a chemical element in the process of disintegration. Nothing we can do will change its rate of decay. One atom in every 10,000 million is breaking up every second and forming new substances. The alchemists' dream of transmutation!—excepting that we have no power to direct the process. Nor is the disintegration complete with one change. Two gases are formed when the radium breaks up: helium and what is called "radium emanation." The atoms of the latter break up further, and again, and again, till, as the final stage in the process, it apparently becomes nothing more nor less than the familiar element lead!

This breaking up of the atom is accompanied by the giving off of prodigious quantities of energy. Not only are particles shot off with enormous velocities, but heat is also liberated. The proportional amount of heat thus produced is more than three and a half million times greater than that from any other known chemical reaction. Prodigious quantities of energy are thus seen to be stored up within the atoms. Not only radium but all elements possess enormous inter-atomic energy; but this energy is unavailable to us at present. One gram of hydrogen is estimated to contain sufficient inter-atomic energy to lift a million tons to a height of over one hundred yards. Our present systems of energy come from actions of groups of atoms. This energy is insignificant compared to that contained within the atoms themselves.

But, let us return again to the consideration of the electron and the part which it plays during chemical reactions. We have seen that atoms are composed of a number of electrons held together by the attraction of a positive electrical force. Elements whose atoms can lose one or more electrons without becoming unstable are electro-positive; those whose atoms can take up one or more additional electrons without becoming unstable are electro-negative. When two such elements are brought together their atoms combine readily because of these opposing tendencies, and we have the evidence of "chemical affinity." Such would be the case with sodium and chlorine. But, under certain conditions the atoms might separate again, and one or more electrons might be dragged from the electro-positive atom by the electro-negative one. This is what presumably happens when sodium chloride is dissolved in water and the molecules "dissociate" in the manner described before.

The atom with its electrons revolving in regular orbits has been likened to the solar system, composed of the sun and the planets. If we imagine the earth reduced to the size of an electron, the total visible universe with its thousand million stars would approximate the size of a human blood corpuscle. To a hypothetical being of the relative size of ourselves, our reduced solar system might well appear as an atom with its electrons appears to us, and, indeed, there would be a remarkable analogy. The revolutions of the planets about the sun would reduce to the same order as those of electrons within the atom; their frequency of vibration would produce a visible light spectrum as do the electrons; the distance between stars would correspond to that between molecules of air. In fact, we would have almost a perfect microcosm.

All these things of which we have spoken—molecules composing all types of matter; atoms composing these molecules, uniting under the forces of "chemical affinity" in all the various ways represented by chemical reactions; electrons, revolving in more or less regular orbits within the electrical sphere of the atom, forming the electric current and causing light, heat, and radiant energy—all of this wonderful field of knowledge has been opened up by modern science, with its marvelous methods of accurate and penetrating research. There still remains much to be done; a great deal of the theory has scarcely passed beyond the mathematical stage. For, after all, though we build our whole structure of scientific knowledge upon this foundation, it is yet a theory, for no one has perceived the molecule, the atom or the electron in its activities. They are creations of scientific thought, although we believe them to exist and can tell in many cases exactly how they act. That is perhaps the most wonderful part of it all—that so much can be known about things which are far beyond the range of direct human perception.

Stream-Valleys and Their Meaning

The three chief processes operative in the development of the "thalweg" of a stream are vertical down-cutting, lateral cutting, and "sweep" or the down-valley migration of the meanders. The first of these is dominant when the bed of the stream is considerably higher than the local equilibrium level, so that the stream tends to cut vertically downward through the subjacent rocks. The result is typically a narrow gorge, with steep sides, and following the course which the stream had before the initiation of the down-cutting. When the gradient is low, the second process is the one which is most active. The stream tends to swing from side to side in its valley, so that a differential wear on the channel ensues. As is well known, the maximum deposition occurs on the inside of the meanders, and a complementary corrosion on the outside. This seems to be mainly due to the current tending to move in a tangential direction at the bends, this tendency increasing with large volume and low gradient. The ultimate form, therefore, is a scalloped outline, with large circular meanders symmetrically arranged. The comparative rarity of this form is due to the operation of the third process, which, in general, is most important, and leaves the greatest ultimate impress on the shape of the valley. In addition to the tangential flow at a bend, there is a strong tendency, due to the down-stream component of gravity, for the stream to take the shortest course, i. e., that round the inside of the bend. The actual course of the strongest current is the resultant of these two, and this explains not only the asymmetric erosion of the meanders, but also the tendency of the latter to migrate down-stream. Circumstances which favor this migration are, low gradient with but little down-cutting, and a large volume of water carrying coarse material. In a river with intrenched meanders the solid rocks resist all three processes, but in a broad valley with rock sides the latter oppose lateral cutting, while the soft alluvial material of the valley-flat offers little resistance to sweep.

The rate of uplift is often an influential factor in determining which of these processes has had the greatest effect. If the uplift be rapid, down-cutting becomes predominant, and the stream entrenches itself in its original course. If the rate of uplift be equal to, or less than, the original rate of down-cutting, lateral cutting and down-valley sweep come strongly into play, with the formation of broad, regular curves, the outsides of which are usually steep and undercut, and the insides smooth and shelving.

J. L. Rich (*Journal of Geology*, July-August, 1914) has classified valleys into three types—Open Valleys, Intrenched Meander Valleys, and Ingrown Meander Valleys—and has considered the formation of each type in terms of these processes. The Open Valley may either be straight or meandering, with wide, open curves and steep sides. The Intrenched Meander Valley, which is apparently the same as the Incised Meander type of other authors, is "one whose stream, having inherited a meandering course from previous erosion cycles, has sunk itself into the rock with little modification of its original course." The windings of the stream follow those of the valley, and river-flats are conspicuously absent. The Ingrown Meander Valley is one which has either developed a meandering course or has expanded an inherited one. This type is characterized by steep, undercut sides on the outside of the curves, and gentle deposition slopes on the inside.

The first of these types is formed when a comparatively straight stream undergoes a rapid uplift. The stream entrenches itself by down-cutting, which continues till grade is reached, when lateral cutting comes into play. This, however, is soon superseded by a down-stream migration of the bends, and the final form is either a broad, open valley, with flat bottom and long, flat curves, or a steep-walled, narrow V-shaped valley. The Intrenched Meander Valley results from the rapid uplift of a meandering stream, which continues to hold its original course, and to entrench itself deeper into the subjacent rocks as long as down-cutting is the principal factor. This type is rarely found, because, when the uplift ceases or becomes slow, Ingrown Meander Valleys develop owing to the operation of the other processes. This third type generally results from the gradual uplift of both straight and meandering streams. The meanders tend to increase through lateral cutting, with the consequent corrosion on the concave sides and deposition on the convex, while sweep leads to asymmetry of the bends, and finally to their down-stream migration. This is particularly the case when uplift ceases and a flood-plain forms.

Obviously the whole three types may be present in a single drainage system, which, for example, undergoes a rapid uplift. The main stream would form an Open Valley where originally straight, and a valley of the second type where originally meandering, while the tributaries of the upper parts would develop Ingrown Meander Valleys, as their rate of uplift would be relatively slow.—*Knowledge.*

Removal of Products of Combustion of Natural Gas from Rooms

Natural gas, when burned with sufficient oxygen for complete combustion, forms carbon dioxide and water vapor. Each cubic foot of natural gas burned produces a little over one cubic foot of carbon dioxide and a little more than two cubic feet of water vapor. Carbon dioxide is an irrespirable gas and should not be allowed to accumulate in a room. Water vapor also should be removed, because it has a depressing effect if present in still, warm air in sufficient proportion and tends to make the walls, ceilings, curtains, and other objects in a room dirty because the dust is entrained by it and settles on the objects.

The only way to remove these two gases is by means of a vent leading from the stove to the house chimney. It is absurd for any manufacturer of stoves to claim that these two gases are practically absorbed or eliminated in any other way. *Technical Paper 109. Bureau of Mines.*

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